

INSTRUCTION BOOK NO. PG565

ISSUE
NO. 2

INSTALLATION, OPERATION AND SERVICE
OF ROUND-CHART DYNAMASTER PYROMETER
IN THE MODEL 565 CASE

FOR SERIAL NO. 66286

**RECORDING
INDICATING
CONTROLLING
TELEMETERING
INSTRUMENTS**



THE BRISTOL CO. WATERBURY 20, CONN.

MP MASTER



MA30033

↓
PLACE THESE INSTRUCTIONS WITH THE MAN IN CHARGE OF YOUR INSTRUMENTS
↑

I M P O R T A N T

- 1 Read these instructions **NOW** before installing instrument.
- 2 Keep these instructions permanently & accessibly filed for future reference.
- 3 Be sure to specify **MODEL & SERIAL** numbers when ordering parts, instructions, diagrams or data.
- 4 Ship instruments or parts for repair or exchange only to Bristol's main or branch factories—not to Sales Offices.
- 5 Be sure to—
 1. Identify your shipments with your **exact** return address & order number.
 2. Write nearest Bristol Factory or office giving your order number, directions & address for return shipment, full instructions for repair, etc.
- 6 Report damage to shipments at once to shipping company. The *customer assumes responsibility for collecting any claim for damages* from the shipping company, on all shipments made on a collect basis.

WHO WILL SERVICE YOUR BRISTOL INSTRUMENT?

Divided responsibility produces misunderstanding and inattention. We therefore urge that all-Bristol instruments in your plant be assigned to the care of one responsible man. He will rapidly become so familiar with routine chart changing, inking, check-

ing and adjusting necessary to keep instruments in good working order, as to require only a few minutes time per day. Bristol will be pleased to supply additional information or personal instruction to instrument service men.

INSTRUCTION BOOK NO. PG565 ISSUE NO. 2

INSTALLATION, OPERATION AND SERVICE
OF ROUND-CHART DYNAMASTER PYROMETER
IN THE MODEL 565 CASE

FOR SERIAL NO. 662866

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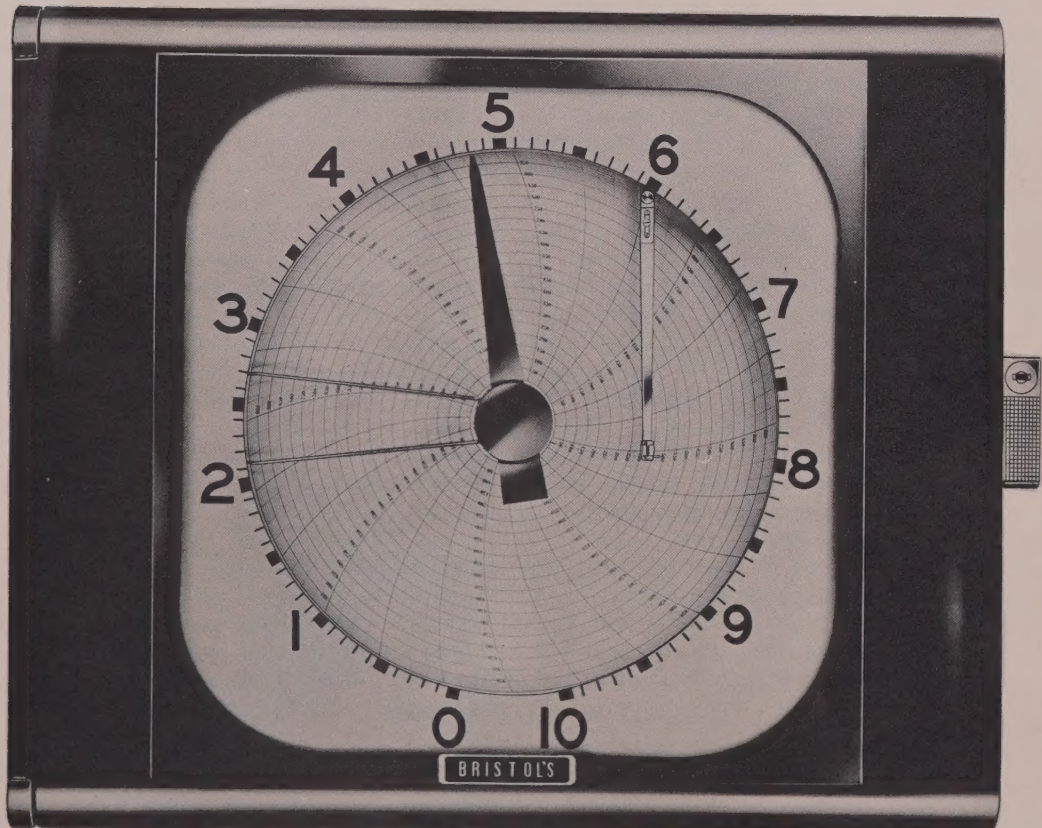
INSTRUCTION NO. P12060

(Issue No. 2 of 1/55)

INSTALLATION, OPERATION AND SERVICE

BRISTOL'S MODEL 565 ROUND-CHART

DYNAMASTER D-C POTENTIOMETER AND D-C BRIDGE



THE BRISTOL COMPANY

WATERBURY 20, CONN.

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Note: This instruction covers the basic balancing, amplifying and recording systems in the Bristol Series 565 Round-chart Dynamaster Potentiometer and D-C Bridge-type Instruments. Separate instructions are provided for the measuring element, controlling system (if one is used) and any special accessories or features.

PART I GENERAL

A. Description

The Dynamaster potentiometer is used with any millivoltage input such as that from thermocouples, photoelectric cells, shunts, magnetos, pH amplifiers, etc.

The Dynamaster d-c bridge is used with any resistance type of measuring element, such as the resistance-thermometer bulb, strain gauge, etc.

A single variable is accurately measured and recorded as a line record on the chart.

The major components of the instrument are:

1. The Potentiometer circuit or bridge circuit
2. The Syncoverter switch
3. The input transformer or pre-amplifier
4. The amplifier
5. The balancing motor
6. The recording system

B. Explanation of Operation

1. The Dynamaster D-C Potentiometer. (See Figure 2) A millivoltage input from the measuring element is connected in series with the potentiometer circuit and Syncoverter switch. There is a standard voltage in the potentiometer circuit which is automatically adjusted

to balance any change in the millivoltage input. Any change in the measuring-element voltage creates a d-c voltage unbalance in the potentiometer circuit. This d-c voltage unbalance is converted to an a-c voltage unbalance by the Syncoverter switch. The Syncoverter a-c unbalance output voltage is then increased by an input transformer or preamplifier before being amplified by the electronic amplifier to a power level sufficient to operate the balancing motor. The balancing motor adjusts the sliding contact on the slide wire to restore electrical balance in the potentiometer circuit and simultaneously moves the pen and pointer to record and indicate, on the chart or scale, the value of the variable being measured.

This balancing action starts with the slightest change in the output voltage of the measuring element. Thus, recording and indicating of the measured quantity are practically instantaneous.

When balance has been restored, the entire potentiometer remains at rest until another change in the measured variable occurs.

2. The Dynamaster D-C Bridge. (See Figure 3) The measuring element forms one leg of the d-c bridge. A d-c power pack supplies 7 to 9 volts d-c to the bridge circuit. When the resistance of the

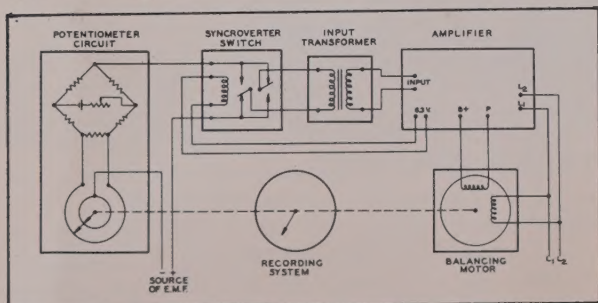


FIGURE 2. SIMPLIFIED SCHEMATIC WIRING DIAGRAM OF DYNAMASTER D-C POTENTIOMETER

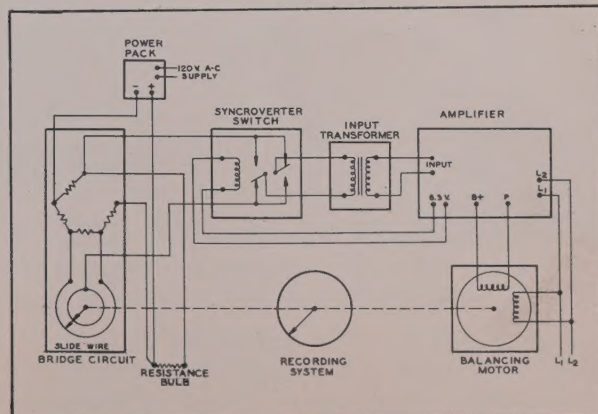


FIGURE 3. SIMPLIFIED SCHEMATIC WIRING DIAGRAM OF DYNAMASTER D-C BRIDGE

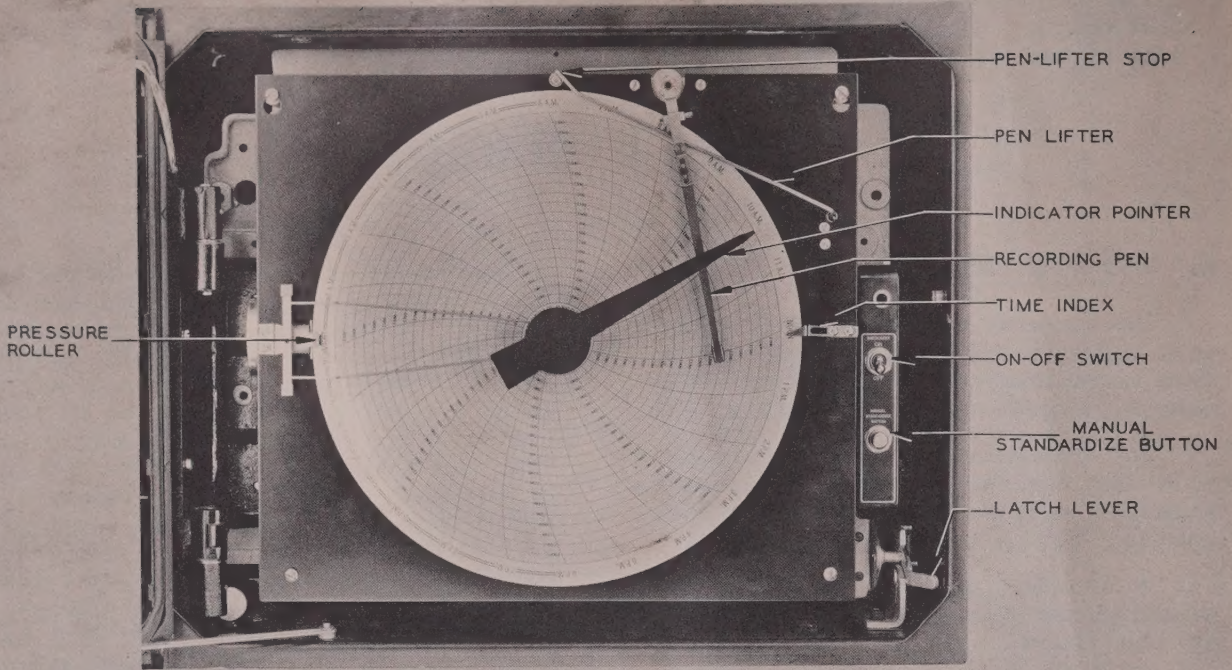


FIGURE 4. FRONT VIEW OF CHART PLATE

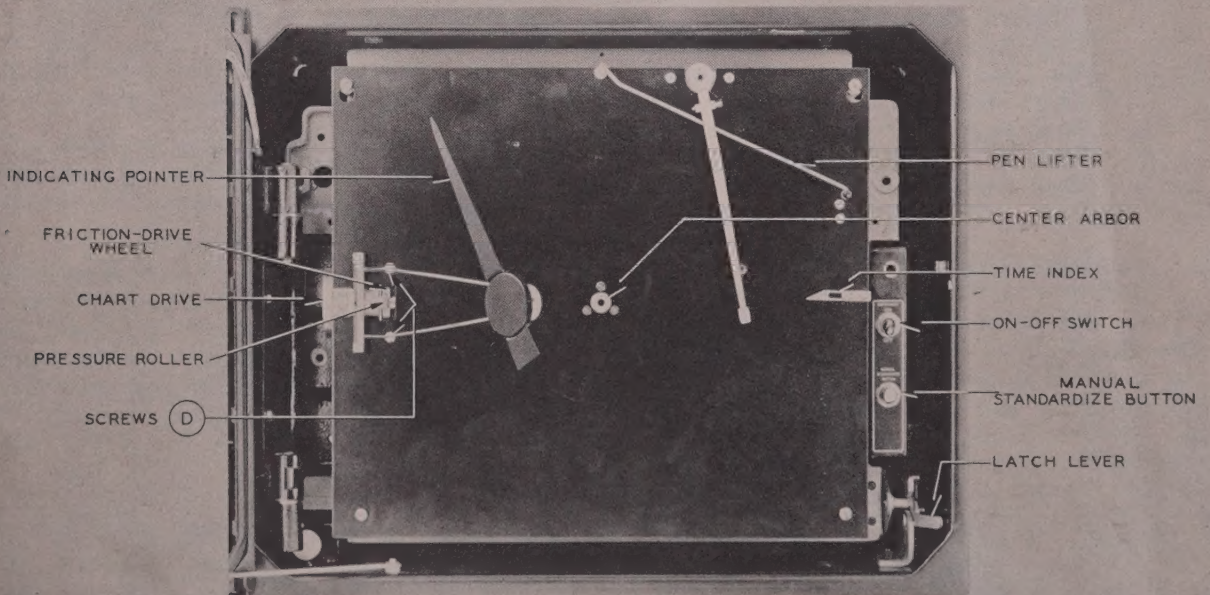


FIGURE 5. FRONT VIEW OF CHART PLATE WITH CHART REMOVED

measuring element changes, current flows in the bridge and a d-c voltage unbalance is created in the bridge circuit. This d-c voltage unbalance is converted to an a-c voltage unbalance by the Syncroverter switch. The Syncroverter a-c unbalance output voltage is then increased by an input transformer or preamplifier before being amplified by the electronic amplifier to a power level sufficient to operate the balancing motor. The balancing motor adjusts the sliding contact on the slide wire to restore electrical balance in the bridge circuit and simultaneously

moves the pen and pointer to record and indicate, on the chart or scale, the value of the variable being measured.

This balancing action starts with the slightest change in the resistance of the measuring element. Thus, recording and indicating of the measured quantity is practically instantaneous.

When balance has been restored, the entire bridge remains at rest until another change in the measured variable occurs.

PART II INSTALLATION

A. Unpacking the Instrument

Do not throw away the packing material until you have found the mounting brackets and screws as shown in the mounting-dimension drawing, and the other accessories, such as ink, charts, spare parts, etc.

B. Locating and Mounting the Instrument

The Dynamaster may be surface mounted or flush panel mounted. Although the instrument is exceptionally free from the effects of dust, dirt, vibration, corrosive fumes and extremes of temperature, it should be located as remotely as possible from such unfavorable conditions. The location should also be convenient for service and general utility.

The instrument should be reasonably level. Proper clearance should be allowed between the Dynamaster and other instruments on the wall or panel, and clearance must be given at the bottom of the case for the wiring or piping connections.

C. External Wiring and Piping

Before connecting any wiring to the Dynamaster, check the voltage and frequency listed on the nameplate of the instrument. To connect the Dynamaster to a voltage greater than 120 volts, a suitable stepdown transformer must be used. All wiring connections are made on the terminal strips mounted inside on the back of the case. The terminals are readily accessible by opening the door of the Dyna-

master and swinging the panel out after first depressing its latch.

The instrument is provided with four holes in the bottom of the case to accommodate standard conduit fittings. Two of the holes accommodate $1\frac{1}{4}$ " conduit connections and the other two accommodate $3/4$ " conduit connections. Conduit should be used whenever possible to bring all electrical circuits into the case. If conduit is not used, the rubber grommets supplied with the instrument should be used to keep the holes as tight as possible.

The wiring diagrams for your particular Dynamaster are provided separately. The measuring circuit is usually covered on one sheet and the power circuit on another sheet. If your instrument is equipped with an electric control or alarm, a third diagram will be furnished covering its wiring.

When connecting the power line to the instrument, make sure that the grounded side of the line is connected to the right-hand power terminal (L_2).

A good ground must be connected to the terminal marked GND.

Note: Do not install measuring circuits such as thermocouple wires in the same conduit with higher-voltage lines.

Piping or tubing will be required if a pneumatic control is supplied in the instrument. Air-control instruments are provided with case connections in the bottom of the case for standard $1/4$ " pipe or $3/8$ " copper tubing.

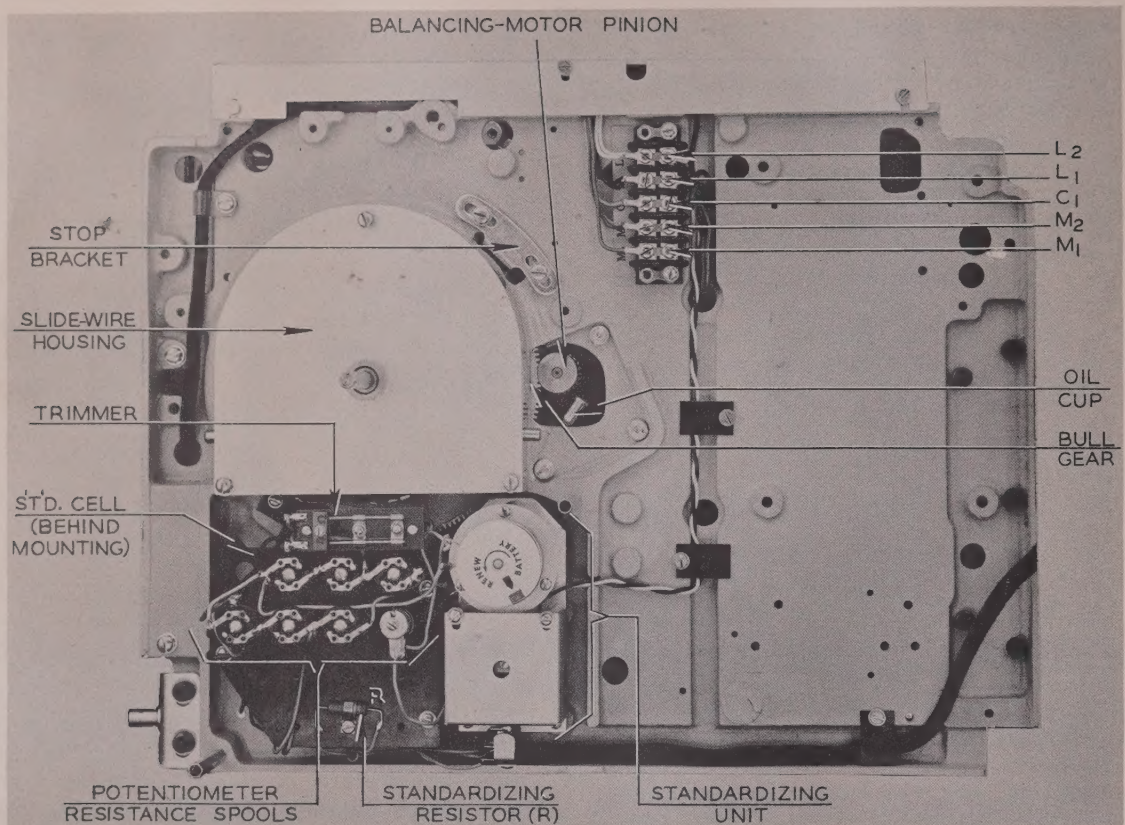


FIGURE 6. REAR VIEW OF HINGED PANEL

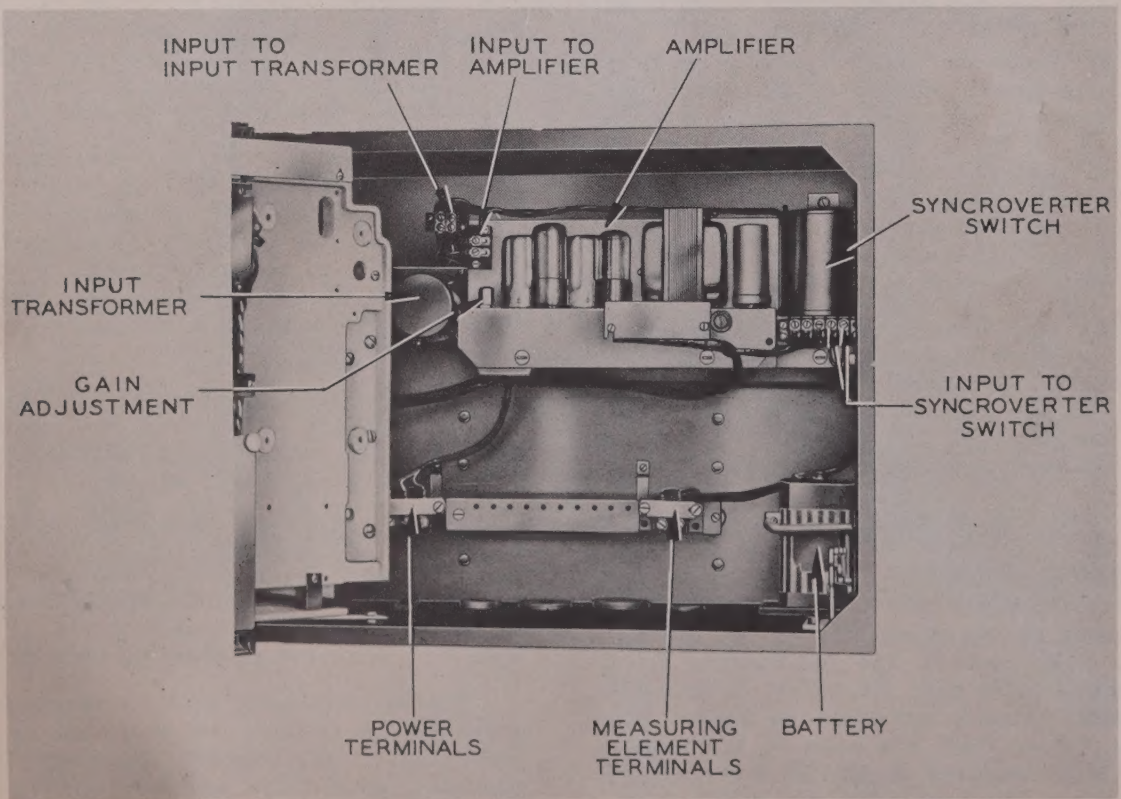


FIGURE 7. INTERIOR OF CASE

D. Installing the Battery

Note 1: This paragraph applies only to potentiometer-type instruments.

Note 2: Some Dynamasters are equipped with a continuous standardization unit which takes the place of the battery and standardizing unit ordinarily furnished. See paragraph C3 Part III if your instrument is equipped with continuous standardization.

A dry cell is shipped separately with

each Dynamaster Potentiometer. In most Dynamasters it is a $1\frac{1}{2}$ -volt dry cell but on certain instruments it may be a 6-volt cell. This battery must be installed, wired and standardized by the user. Install battery in lower right-hand side of the case as shown in Figure 7. The yellow wire goes to the positive terminal (center) and the green wire to the negative terminal (outside).

See paragraph C Part III for instructions on how to standardize the battery.

PART III OPERATION

A. Starting the Dynamaster

To start the Dynamaster after it has been completely and correctly wired, simply turn on the instrument on-off switch. Nothing further need be done. If your Dynamaster is equipped with a control unit or other accessory, see separate instructions provided for its operation.

B. Stopping the Dynamaster

To stop the Dynamaster, merely turn off the instrument on-off switch. For a prolonged shutdown, the instrument should be stored in a clean, dry place.

C. Standardization

Three methods of current standardization are furnished in the Bristol Dynamaster Potentiometer. Unless otherwise specified, the manual push-button standardization is furnished as standard with all round chart Dynamasters.

1. Manual Push-button Standardization. To standardize, turn instrument power switch on. Allow 30 seconds for tubes to warm up. Press standardizing button and hold it down until the pen becomes stationary. Standardization is required when starting up for the first time, after installing a new battery and once a day thereafter.

2. Intermittent Automatic Standardization. This method utilizes a push button as well as a timer which periodically standardizes the current. To standardize, turn instrument power switch on. Allow 30 seconds for tubes to warm up. Press the manual standardizing button and hold it down until the pen becomes

stationary. Manual standardization is required only when starting up for the first time or after installing a new battery. Standardization thereafter is taken care of automatically.

3. Continuous Standardization.

Continuous standardization may be supplied with any Bristol D-C Potentiometer-type Dynamaster. Continuous standardization takes the place of the battery and the manual or automatic standardization ordinarily furnished.

Continuous standardization requires the use of a constant voltage source, a push-button switch and a rheostat. The constant voltage source is located in the lower-right-rear corner of the case where the battery is normally located. The push-button switch and rheostat are located on the resistance-spool card which is mounted below the slide-wire on the back of the hinged panel.

a. Adjustment. When the Dynamaster is first installed, the constant voltage source should be adjusted for the optimum voltage conditions under which it will operate. To do this, turn on the instrument and allow it to warm up for at least 30 minutes. Pen should be at some steady value on the chart and away from either extremity of the chart range. Remove cover from spool card. Press push-button switch and turn rheostat with a screw driver until there is no movement of the pen. This adjustment is not critical and need only be checked about twice a year.

D. Amplifier Gain Adjustment

The only time the amplifier gain adjustment need be checked is after chang-

ing tubes or doing other service work on the amplifier, and about once every 3 to 6 months thereafter. The reason for the periodic check is because the vacuum tubes age with use. While this check is being made, the measured variable should be at a steady value.

To check amplifier gain, proceed as follows:

Allow amplifier to warm up for at least 2 minutes. Remove the cap on the gain adjusting screw (see Figure 7 or 11). Turn the balancing-motor pinion (drive gear) manually to the right and release it. Then turn pinion to the left and release it. The pen should return quickly to its original position each time. If it does not return to its original position completely and quickly, it indicates that the amplifier gain (or sensitivity) is too low. To increase the gain, turn gain adjusting screw in a clockwise direction. When the gain adjustment has reached its maximum clockwise direction, the amplifier lacks sensitivity and requires new tubes.

There is an optimum position for the gain control. If the gain is too low, the pen will not return quickly to its proper value when the balancing motor is manually shifted off balance. If the gain is too high, the pen may "hunt" (mechanical oscillation of the pen). On some instruments if an abnormal pickup in the external measuring circuit is present, it is possible to turn the gain high enough to overload the amplifier and cause the balancing motor to act sluggishly. This condition can be corrected by reducing the gain (turning gain adjustment counter-clockwise).

E. How to Change Charts

1. **To Remove Chart.** (See Fig. 4 & 5.) Grasp indicating pointer by the hub and pull gently to release it from the center arbor. Swing pointer to the left out of the way. Move pen lifter down to lift pen from the chart. Slide time index to the right. Grasp chart by its lower edge and pull it off the center arbor.

2. **To Replace Chart.** Place the new chart on the center arbor, making sure that the left-hand edge is between the pressure roller and the friction-drive wheel. Slide time index to the left over the chart edge. Rotate chart until time index points to the correct time division

on the chart. Lower pen back on chart by moving pen lifter upward. Pen lifter should be moved upward as far as its stop. Swing the indicating pointer into position on the center arbor. Press it gently against the center arbor and rotate it until the setscrews in the indicating-pointer hub line up with the slots in the center arbor. Then push indicating-pointer hub firmly into place. A permanent magnet in the indicating-pointer hub holds the pointer in place.

F. Inking the Pen

1. **Fountain pen.** Add ink to the pen by using the glass dropper which forms the stopper for the 1-ounce bottle of ink furnished with each recorder.

The pen should be kept at least a quarter full of ink. If it clogs or draws a poor record, clean it with the wire pen cleaner provided. If necessary, wash pen with soap and warm water.

2. **Reservoir pen feed, Attachment T77**
The reservoir for this model is located in back of the chart plate and is readily accessible when the hinged panel is swung out. This reservoir should be filled with ink and adjusted so that the ink level in reservoir does not exceed the height of the pen when the pen is at its lowest position.

Check zero before operating instrument. With power off, run pen to the bottom of the chart by turning motor shaft by hand. When motor gear is against stop, adjust pen to the zero line by means of the micrometer adjustment at the top of the pen arm.

Start the pen by using the pen starter supplied. Squeeze the bulb of the pen starter. Place the pen in the hole on the stem of the starter. Release the bulb and allow the starter to suck the ink into the pen.

When the reservoir needs refilling, empty the reservoir and wash out with warm water before refilling. Do not continue to add to ink supply because ink will eventually thicken and plug the pen. Always wash out reservoir between each filling.

G. Alignment of Pen

To check the alignment of the pen with the zero or low end of chart, turn balanc-

ing-motor pinion (with power off) until the stop at the low end of scale is reached. Use micrometer adjustment on pen arm to reset pen to zero or low end of chart range.

H. Alignment of Indicating Pointer

To check the alignment of the pointer with the zero or low end of scale turn balancing-motor pinion (with power off) until the stop at the low end of scale is reached. If the pointer does not line up properly with the zero or low end of scale, it may be realigned as follows:

Grasp indicating pointer by its hub and pull it out from the center arbor. Swing the indicating pointer to the left as far as possible. Note that the pointer has slotted holes in it and is held in place on its hub by two screws. When these screws are loosened, the pointer may be moved as required to realign the pointer with the low end of scale. Retighten the two screws after alignment is completed.

I. Chart Drive

The chart drive used on the Model 565

is a friction-type chart drive powered by a 3-watt, self-starting synchronous motor which depends for its timing on the frequency of the alternating-current supply. Therefore, the frequency must be exactly as listed on the nameplate in order to obtain accurate chart timing. A supply-voltage variation of plus or minus 10% or less will not affect accuracy of timing. Electric chart drives will restart automatically after power failure, but lost time must be made up by manually advancing the chart until the correct time division is indicated by the time index.

The chart-drive motor is mounted behind the chart plate, and its friction-drive wheel makes contact with the chart thru a slot in the left-hand side of the chart plate. A nylon roller, mounted on the spring bracket which is part of the indicating-pointer assembly, exerts pressure on the front of the chart, forcing the chart against the friction-drive wheel only when the indicating-pointer hub is pushed in against the center arbor. When the indicating pointer is swung out from the center arbor, the chart drive will not rotate the chart.

PART IV SERVICE

Service to the Bristol Dynamaster requires complete familiarity with the instrument. Other than routine preventive maintenance should be done only by a qualified technician, or the instrument should be returned to the Bristol Company for service.

A. Routine Maintenance

1. **Lubrication.** Balancing motors with enclosed gear trains must have their front and rear bearings oiled at least once every three months with Gulf electric motor oil. An oil cup is provided for the rear bearing. Wipe any excess oil from the overflow hole after oiling.

Balancing motors equipped with an open gear train have ball bearings which require no lubrication.

Put 2 drops of light machine oil in the hole of the center arbor about once every 3 months.

Nothing else should be oiled in the Dynamaster. All other bearings are either

dry (and should be kept clean) or are permanently sealed and require no lubrication during their normal lifetime.

2. **Replacement of the Battery.** This paragraph does not apply to d-c bridge-type instruments or to instruments equipped with a constant-voltage source.

The battery life depends upon operating conditions and usage. Generally it will last 6 to 12 months. It is very desirable to have a regular replacement schedule. When the battery becomes seriously weak, a red signal appears thru an opening in the cover of the standardizing unit. The battery must be changed when this signal appears. Replace the old battery with a $1\frac{1}{2}$ -volt dry cell (see note below) and standardize it manually as described in paragraph D, Part II.

Note: Some instruments use a 6-volt battery instead of the usual $1\frac{1}{2}$ -volt cell. When replacing a battery, be sure that the new battery has the same voltage rating as the one being replaced.

3. Replacement of Chart Drive. Turn power switch off. Disconnect motor leads from power-supply terminals L_1 and L_2 on back of panel. Remove screws (Item D in Figure 5). This permits the motor and motor mounting bracket to be removed as a unit. Remove old motor from mounting bracket. Install new motor on mounting bracket and mount complete unit on chart plate. After mounting the new motor, connect the motor leads to L_1 and L_2 terminals on back of panel.

4. Replacement of Balancing Motor. Turn power switch off. Refer to Figure 8. In order to replace the balancing motor, it is first necessary to remove the chart plate. Remove screws B and loosen screws A. Loosen slotted screw C on flexible coupling.

Caution: Do not, under any circumstance, loosen the setscrew at the other end of flexible coupling because this will disturb the calibration of the instrument.

After screws A and C have been loosened, the chart plate may be lifted slightly and removed.

Disconnect the motor leads from terminal block and remove the three nuts holding the motor on the panel. After the new motor has been installed, be sure to check the power-circuit wiring diagram so that the motor leads are connected up properly. Also make sure that the motor pinion meshes with the bull gear without binding.

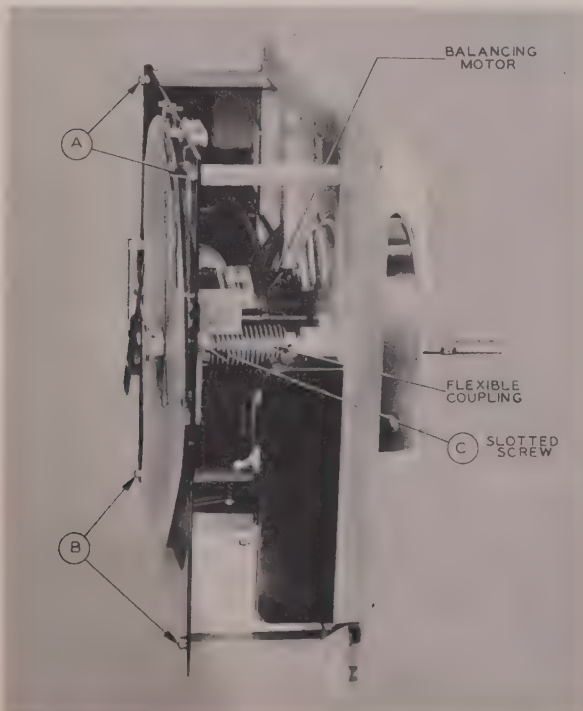


FIGURE 8. END VIEW OF CHART PLATE AND PANEL

B. Suggested Service Equipment

1. Stock of Replacement Parts. It is suggested that the following replacement parts be kept in stock. The vacuum tubes listed below are standard types and are available at any radio supply store:

Type 6X5 rectifier tube

Type 6V6 power amplifier tube

Type 7F7 voltage amplifier tube

Plug-in-type electrolytic filter capacitor with octal base (10-10-10 mfd. 450 volt) **Note:** Electrolytic capacitors deteriorate in storage. Their shelf life should not be over 18 months. Replacement electrolytic capacitors can be kept in usable condition indefinitely by placing them in service in the Dynamaster for an hour or two every six months.

Fuses for amplifier (1-ampere Littlefuse for Series C Amplifier. 1/8-ampere Littlefuse for Series C-1 amplifier)

Dry cell ($1\frac{1}{2}$ or 6 volt as required for potentiometers only)

Amplifier. Where several Dynamasters are in use or where continuous instrument performance is of critical importance, it is recommended that spare replacement amplifiers be kept in stock.

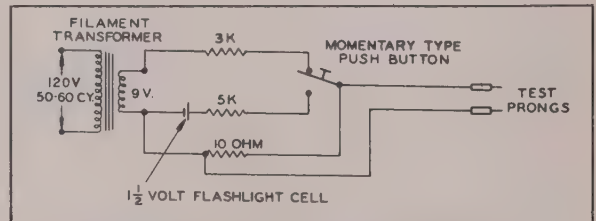


FIGURE 9. WIRING DIAGRAM OF DYNAPROBE

2. Test Equipment

A signal generator, such as Bristol's Dynaprobe Part No. 91054, is highly recommended because it provides a quick means for isolating trouble in the detection circuit of the Dynamaster without having to remove the Dynamaster from service or disconnecting the input circuit or the power to the instrument.

The Dynaprobe consists of a covered metal box connected by 40 inches of flexible wire to a two-prong probe enclosed in a small Bakelite housing. The metal box is fitted with a standard socket to provide 120 volts ac for use of a solder-

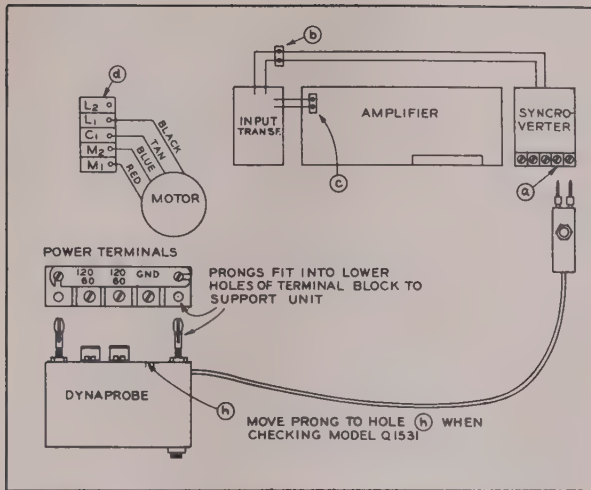


FIGURE 10. SKETCH SHOWING CHECK POINTS IN DYNAMASTER FOR DYNAPROBE.

ing iron. The back of the box is fitted with two prongs and two spring-type connectors. The prongs on the back of the unit plug into the power terminal block of the Dynamaster, allowing the spring connectors to make contact with the 120-volt power circuit.

The probe unit is fitted with a spring push button. When the button is depressed, approximately 3 millivolts dc is available at the test prongs. The battery used is a standard 1.5-volt flashlight battery. The battery should be replaced every 6 months. When the button is released, approximately 30 millivolts ac is available at the test prongs. The proper use of the Dynaprobe is covered in succeeding paragraphs.

An a-c voltmeter or test lamp is required to perform the power-supply check.

An ohmmeter is convenient when checking the continuity of the measuring system.

On potentiometer-type instruments, a potentiometric test set is required (one with ranges 0 to 150 millivolts and 0 to 1.5 volts).

On d-c bridge-type instruments, a set of test resistance spools is handy for checking resistance measuring instruments. The Bristol Company manufactures a set of very accurate test resistance spools. Spools may be ordered by the set or singly for any value. Ordinary variations in room temperature do not affect their accuracy.

C. Systematic Trouble-shooting Procedure

Should the Dynamaster fail in any way, it is first necessary to determine which part is faulty. The following systematic procedure is suggested in order that repairs may be accomplished with a minimum of lost time and expense.

1. **Power-supply Check.** Using a 150-volt-range a-c voltmeter (or test lamp), check for line voltage across instrument power terminals, instrument power switch, L_1 and L_2 terminals on back of swinging panel, and also L_1 and L_2 terminals on amplifier.

2. Balancing-motor Check

Caution: Always be sure to turn power switch off before shifting the two control-winding wires because of the high voltage (300 volts) across terminals M_1 and M_2 .

a. On instruments with the **Series C amplifier**. Turn power switch off. Remove the two control-winding wires at terminals M_1 and M_2 (Figure 6) and then put these wires across terminals L_1 and L_2 on the same terminal block. Turn on power switch. The motor should move the pen up or downscale (depending upon phase). Next, reverse these wires from the control winding. The motor should move the pen in the opposite direction. If the balancing motor fails to move the pen up or downscale with the above tests, it could mean that one of the following conditions exists:

1. No power to balancing motor.
2. Balancing motor defective.
3. Mechanical failure between balancing-motor pinion, bull gear and recording-pen shaft.

b. On instruments with the **Series C-1 amplifier**. Turn off power switch. Remove the two control-winding wires from terminals M_1 and M_2 . Connect these wires across terminals L_1 and L_2 with a 1-microfarad capacitor in series with one of the wires. Turn on power switch. The motor should move the pen up or downscale (depending upon phase). Next, reverse these wires from the control winding. The motor should move the pen in the opposite direction. If the balancing motor fails to move the pen up or downscale with the above test, it could mean that one of the following conditions exists:

1. No power to balancing motor.
2. Balancing motor defective.
3. Mechanical failure between balancing-motor pinion, bull gear and recording-pen shaft.

3. The Amplifier. Plug Dynaprobe into terminal block and apply test prongs across the input terminals of the amplifier (see Figure 11). If amplifier is working properly, the balancing motor will move the pen up or downscale (depending upon phase). Reversing the two test prongs will cause the balancing motor to move the pen in the opposite direction. If the balancing motor does not move the pen up or downscale, disconnect the input leads to amplifier and check again with the test prongs across input terminals to amplifier. If the balancing motor still does not move the pen up or downscale, check fuse in amplifier, replace vacuum tubes and filter capacitor in amplifier. If this does not work, replace the amplifier.

Note: The Bristol Company recommends that service work inside the amplifier chassis should not be attempted by the average user. Service work on electronic circuits is a specialized technique requiring special test equipment for efficient results. For users having available an electronic technician and adequate test facilities, The Bristol Company has prepared service instructions for the amplifier which contain a detailed circuit diagram, testing data and procedure for checking the amplifier. A copy of this instruction is furnished with each Dynamaster.

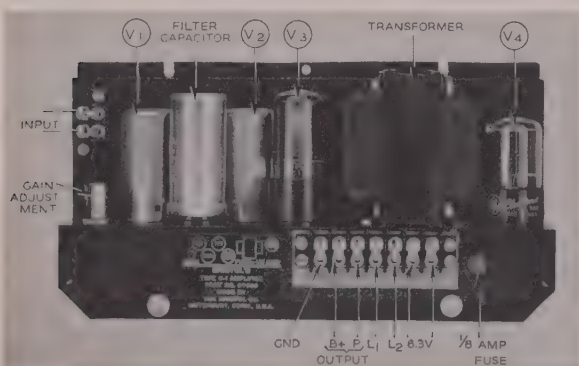


FIGURE 11. SERIES C-1 AMPLIFIER

4. Input Transformer or Preamplifier. (See Fig. 7) Apply test prongs from Dynaprobe to input terminals of input transformer or preamplifier (pink and yellow wires). If input transformer is functioning properly, the balancing motor will move the pen up or downscale (depending upon phase). Reversing the test

prongs will cause the balancing motor to move the pen in the opposite direction. If the balancing motor does not move the pen up or downscale, disconnect the input leads to transformer or preamplifier and check again with the test prongs across input terminals to transformer or preamplifier. If pen still does not move up or downscale with this test, the input transformer or preamplifier is defective and should be replaced.

5. Syncroverter® Switch. (See Fig. 12) With the push button on Dynaprobe depressed to provide a d-c signal, apply test prongs to input terminals of Syncroverter switch (orange and brown wires). If Syncroverter switch is functioning correctly, the balancing motor will move the pen up or downscale (depending upon phase). Reversing the test prongs will cause the balancing motor to move the pen in the opposite direction. If the balancing motor does not move the pen up or downscale, disconnect the orange and brown wires from Syncroverter switch and check again with the test prongs. If the balancing motor still does not move the pen up or downscale with this test, the Syncroverter switch is defective and should be replaced.

If steps 1 thru 5 above have been performed and all of the components function correctly but the instrument still fails to function, the fault probably lies in the measuring system of the instrument.

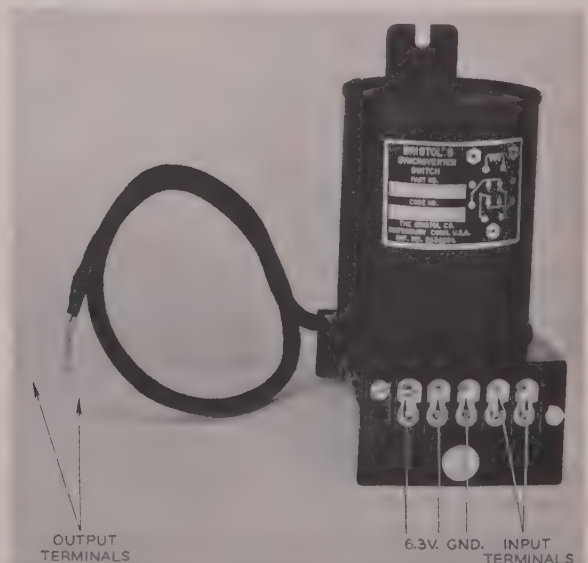


FIGURE 12. SYNCROVERTER SWITCH

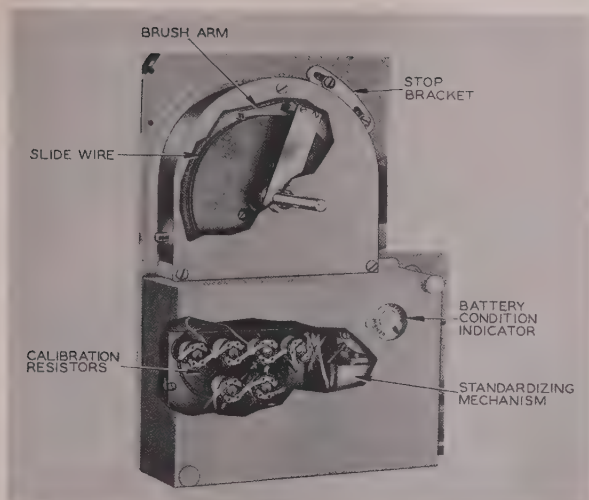


FIGURE 13. POTENTIOMETER UNIT WITH CASE CUTAWAY

6. Measuring System on Potentiometers

The potentiometer type of Dynamaster uses the null-balance potentiometer circuit. From the simplified schematic wiring diagram (Fig. 2) it will be noted that the measuring element is wired in series with the potentiometer circuit, Syncroverter contacts and primary winding of the input transformer. This means that an open circuit anywhere in the measuring circuit, slide wire, Syncroverter contacts or primary winding of the input transformer will produce the same result: no error signal in the circuit and consequently no output from the amplifier to the balancing motor.

Check carefully the particular measuring element used to see that it is functioning correctly. Check particularly the wiring connections at both the measuring element and the instrument. Disconnect the measuring-element leads from the instrument and connect them to a potentiometric test set to be sure that the measuring element is producing the voltage required for the existing conditions. See separate instructions covering servicing and checking procedures for the particular measuring element used.

Caution: Never put an ohmmeter across any part of the measuring system without first disconnecting the input leads to the Syncroverter switch. The reason for this is that the ohmmeter produces a relatively high current and would damage the Syncroverter contacts.

Assuming that the measuring element and its leads have been eliminated as the source of trouble, proceed as follows:

a. Check battery voltage (1.5 or 6.0 volts depending upon the instrument).

b. Check standard-cell voltage (1.0185 to 1.0195 volts).

c. Check voltage across E spool (1.0185 to 1.0195 volts).

d. Check contacts on standardizing relay to see that they make good contact. This may be done by pushing the contacts down with a non-metallic object. The contacts may be cleaned with carbon tetrachloride or other solvent if they appear dirty.

e. Check to see that the slide-wire brush arm makes good contact with the slide wire. Try cleaning slide wire with carbon tetrachloride or other solvent. Allow to dry. Then apply a small amount of vaseline to slide wire and wipe off excess with a clean cloth.

If all of the above checks have been performed and the instrument still fails to function, the possible fault may be either an open circuit or a short circuit somewhere in the measuring system. Look for loose or poor connections or possibly a dab of solder that might short out two connections.

7. Measuring System on D-C Bridges.

From the simplified schematic diagram (Fig. 3) it will be noted that the measuring element is wired so as to form one leg of the bridge. An open circuit anywhere in the bridge will produce an infinite resistance, driving the pen to the top or bottom of the scale depending upon what portion of the bridge is open-circuited. If an open circuit is suspected, it can easily be checked with an ohmmeter. See separate instructions covering servicing and checking procedures for the particular measuring element used.

Caution: Never put an ohmmeter across any part of the measuring system without first disconnecting the input leads to the Syncroverter switch. The reason for this is that the ohmmeter produces a relatively high current and would damage the Syncroverter contacts.

Assuming that the measuring element and its leads have been eliminated as the source of trouble, proceed as follows:

a. Check output voltage of power pack (7 to 9 volts d-c).

b. Check to see that the slide-wire brush arm makes good contact with the slide wire. Try cleaning slide wire with carbon tetrachloride or other solvent. Allow to dry. Then apply a small amount of vaseline to slide wire and wipe off excess with a clean cloth.

If all of the above checks have been performed and the instrument still fails to function, the possible fault may be either an open circuit or a short circuit somewhere in the measuring system. Look for loose or poor connections or possibly a dab of solder that might short out two connections.

D. Repairs, Correspondence and Shipping

If the Dynamaster cannot be repaired with the information furnished in this instruction, it should be shipped to the nearest Company Branch or Main Factory for repair or replacement. Do not ship instruments to Branch Offices. Be sure to mark your return address plainly.

In all correspondence please mention the instrument model and serial number (as listed on its nameplate) and your repair order number. Address all correspondence to the Bristol Company Branch or Main Offices, a list of which is found in all instruction manuals.

INSTRUCTION NO. P12072

(Issue No. 1 of 1/55)

SERVICE INSTRUCTIONS

FOR THE SERIES C-1 AMPLIFIER

(120-volt, 60-cycle supply only)

PART I INTRODUCTION

This instruction covers the service of the Series C-1 amplifier used on Bristol Dynamasters with a 120-volt, 60-cycle supply.

Service work on electronic circuits is a specialized technique requiring special test equipment. Only a qualified electronic technician should attempt service inside the amplifier chassis.

If a qualified technician is not available, the amplifier should be returned to the nearest Bristol Company Branch or Main Factory for repair. Adequate stocks of guaranteed, factory-rebuilt exchange amplifiers are maintained at several points throughout the country to assure fast replacement. Contact nearest Bristol office as listed on last page of all instruction books.

PART II TEST EQUIPMENT

Multirange volt-ohmmeter with ranges 0 to 50 and 0 to 500 volts d-c, 0 to 4000 and 0 to 500,000 ohms resistance, voltage sensitivity 20,000 ohms per volt.

A signal generator, such as Bristol's Dynaprobe Part No. 91054, is recommended

for producing a test input signal. Figure 1 illustrates how a signal generator can be made.

Cathode-ray oscilloscope with an input impedance not less than 500,000 ohms and a vertical sensitivity of .03 volts.

PART III TEST PROCEDURE

Disconnect all leads to amplifier and remove amplifier from Dynamaster. The amplifier may be removed by loosening the rear mounting screws and unlocking the quick fasteners on the front of the chassis.

Connect a 5000-ohm 10-watt resistor across the output terminals of the amplifier.

Caution: Never check an amplifier without first connecting the 5000-ohm resistor across the output terminals of

the amplifier.

Connect a 120-volt, 60-cycle power supply to power terminals marked L_1 and

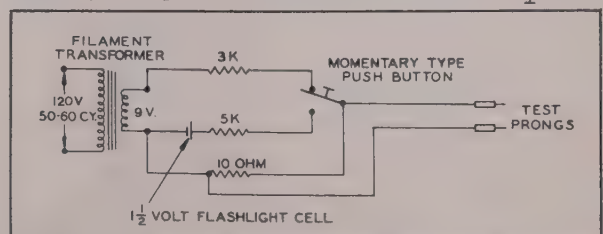


FIGURE 1. WIRING OF TEST INPUT-SIGNAL GENERATOR

Measure		Correct Voltage	Recommended Correction	
From	To		If Voltage Is Too Low	If Voltage Is Too High
B+	Gnd.	360 ± 10	Replace V_4 & plug-in capacitor No voltage. Replace fuse.	Replace V_3
B_5	Gnd.	355 ± 10	Replace plug-in capacitor	Replace V_3
B_4	Gnd.	330 ± 10	Replace plug-in capacitor	Replace V_1 or V_2
B_3	Gnd.	260 ± 10	Replace plug-in capacitor	Replace V_1 or V_2
S_C	Gnd.	335 ± 10	Replace V_3	Replace V_3 Check R_{23}
B_{1-2}	Gnd.	220 ± 10	Replace plug-in capacitor Check C_{21}	Replace V_1
P_5	Gnd.	240 ± 10	Check voltage at B_5	Replace V_3
P_4	Gnd.	290 ± 10	Check voltage at K_4	Check R_{19}
P_3	Gnd.	145 ± 10	Check voltage at K_3	Check R_{15}
P_2	Gnd.	115 ± 10	Check voltage at K_2	Check R_7
P_1	Gnd.	115 ± 10	Check voltage at K_1	Check R_3
K_5	Gnd.	24 ± 3	Check C_{16}	Check R_{23}
K_4	Gnd.	4.8 to 5.7	Check C_{13} & R_{19}	Check R_{18}
K_3	Gnd.	2.3 ± 0.5	Check C_{10}	Check R_{14}
K_2	Gnd.	1.8 ± 0.5	Check C_4	Check R_6
K_1	Gnd.	1.8 ± 0.5	Check C_1	Check R_2
Note: Points K_1 , K_2 , etc., were marked C_1 , C_2 , etc., on earlier models.				

FIGURE 2. TABLE OF D-C VOLTAGE CHECKS BASED ON A LINE VOLTAGE OF 117 VOLTS AND A 5000-OHM 10 WATT RESISTOR ACROSS THE OUTPUT TERMINALS OF AMPLIFIER

L_2 . This is the nominal operating voltage and any variation from it will produce slightly lower or higher test readings.

Warning: There are dangerous voltages in the amplifier. Never touch any part with bare hands unless the power is off.

A. D-C Voltmeter Check

A quick method of locating the defective stage is by the use of a d-c voltmeter.

With the amplifier removed from the instrument, proceed as follows:

1. Connect a 5000-ohm 10-watt resistor across the output terminals of the amplifier.

2. Connect a 120-volt, 60-cycle supply to power terminals (L_1 and L_2).

3. Turn gain control to zero (extreme counterclockwise position).

4. Connect negative lead of voltmeter to the ground connection on the amplifier. Test with the other voltmeter lead at the points listed in table, Figure 2.

The voltages given in the table (Figure 2) were taken with a 20,000 ohm per volt meter and with a line voltage of 117 volts. If the line voltage is greater or less than 117 volts, the d-c voltage given in the voltage table will vary proportionally. **For example:** If the line voltage is 110 volts, the B+ voltage instead of being approximately 360 volts

$$\text{will be } \frac{110}{117} = \frac{x}{360} \text{ or } x = \frac{110 \times 360}{117} = 338.$$

Therefore, the B+ voltage will be approximately 338 volts with a line voltage of 110 volts.

For optimum damping and sensitivity, the voltage between K_4 and ground should not vary more than specified values.

All d-c voltages above 100 volts should not vary more than ± 10 volts from specified values.

Voltages between K_1 , K_2 and K_3 and ground should not vary more than ± 0.5 volts from specified values.

Voltage between K_5 and ground should not vary more than ± 3 volts from specified value.

If B₊ is low, replace V₄. If B₃, B₄ or B₅ is low, replace the plug-in filter capacitor with one known to be good. This capacitor contains C₁₈, C₁₉ and C₂₀.

B. Testing with an Oscilloscope

For those who desire to locate the defective stage by tracing a test input signal step by step thru the amplifier with an oscilloscope, the following procedure should be followed:

1. Connect a 5000-ohm 10-watt resistor across the output terminals of the amplifier.

2. Connect a 120-volt, 60-cycle supply to the power terminals (L₁ and L₂).

3. Connect the a-c test input signal from the signal generator to the amplifier input terminals.

4. Turn the gain adjustment to its maximum position (extreme clockwise position).

5. Connect the ground side of the oscilloscope to the amplifier chassis ground.

6. Connect test voltage to the vertical input terminals (Y axis) of the oscilloscope. Then, adjust horizontal sweep rate, as required, until a sine-wave pattern appears on the scope. See also directions furnished with oscilloscope.

G₁ **Signal:** Sine wave on screen. Note amplitude for comparison with the following tests.
No Signal: Check signal generator.

P₁ **Signal:** Amplitude should be about 40 times G₁.
No Signal: Defect in first stage. Check V₁. Check voltage from K₁ to ground and P₁ to ground (see d-c voltage table, Figure 2).

X₁ **Signal:** Same as P₁.
No Signal: Check C₂ and R₄.

G₂ **Signal:** Slightly less than P₁.
No Signal: Check C₃, R₄ and R₅.

P₂ **Signal:** Amplitude should be about 40 times greater than G₂.
No Signal: Defect in second stage. Check V₁. Check voltage from K₂ to ground and P₂ to ground (see d-c voltage table, Figure 2).

Next, reduce gain until setting on oscilloscope and picture approach

original at G₁. Note amplitude for comparison with following test.

X₂ **Signal:** Amplitude about 1/5 that of P₂. If signal is abnormally high or low, check R₈, R₉, R₁₀, C₅, C₆, C₇ and R₁₁. If fault is found in this section, replace entire board or return amplifier to factory.

X₃ **Signal:** Same as X₂.
No Signal: Check C₈ and R₁₂.

G₃ **Signal:** Amplitude should be about the same as X₃.
No Signal: Check C₉ and R₁₃.

P₃ **Signal:** Amplitude should be about 50 times G₃.
No Signal: Defect in third stage. Check V₂. Check voltage from K₃ to ground and P₃ to ground (see d-c voltage table, Figure 2).

X₄ **Signal:** Same as P₃.
No Signal: Check C₁₁ and R₁₆.

G₄ **Signal:** Less than X₄.
No Signal: Check C₁₂ and R₁₇.

Next, reduce gain until setting on oscilloscope and picture approach original at G₁. Note amplitude for comparison with following test.

P₄ **Signal:** Amplitude should be about 14 times G₄.
No Signal: Defect in fourth stage. Check V₂. Check voltage from K₄ to ground and P₄ to ground (see d-c voltage table, Figure 2).

G₅ **Signal:** Approximately 1/4 that of P₄.
No Signal: Check C₁₄, C₁₅ and R₂₁.

X₅ **Signal:** Same as G₅.
No Signal: Check R₂₂.

P₅ **Signal:** Amplitude should be about 6 times G₅.
No Signal: Defect in fifth stage. Check V₃. Check voltage from K₅ to ground and P₅ to ground (see d-c voltage table, Figure 2).

P **On terminal strip**
Signal: Same as P₅.
No Signal: Check connections between P and P₅.

C. Identifying Defective Part

When the defective stage is located from the above checks, the defective part of that stage may be identified. This is

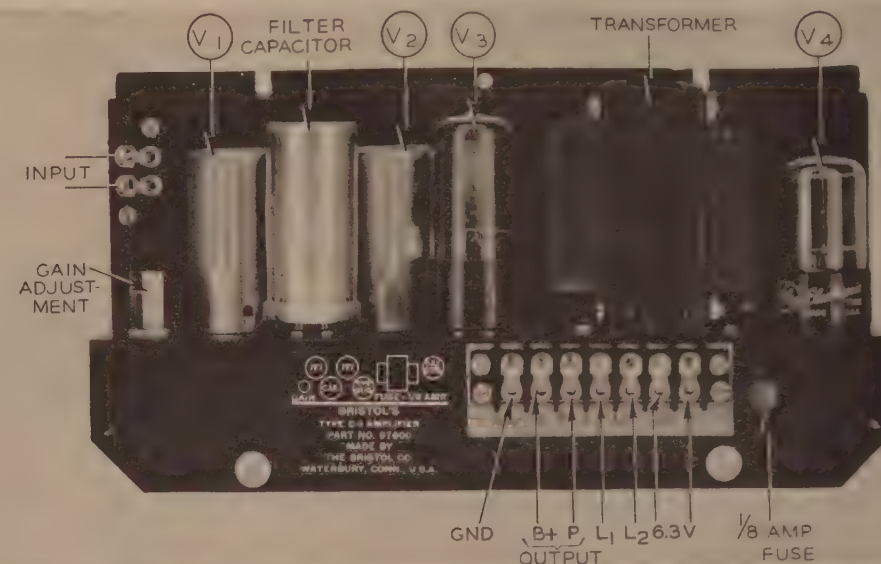


FIGURE 3. FRONT VIEW OF SERIES C-1 AMPLIFIER

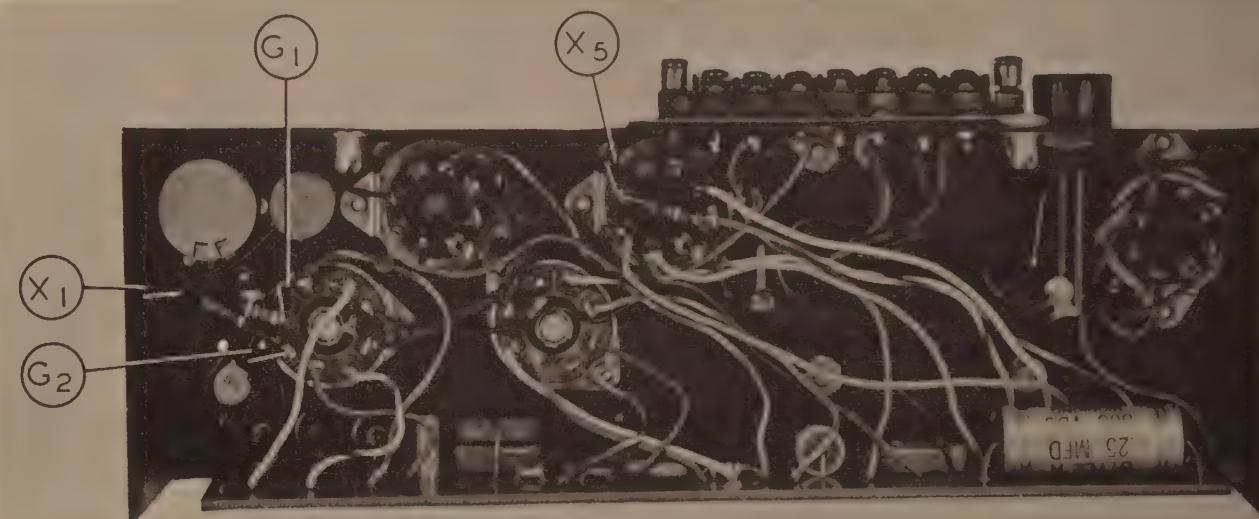


FIGURE 4. BOTTOM VIEW OF SERIES C-1 AMPLIFIER

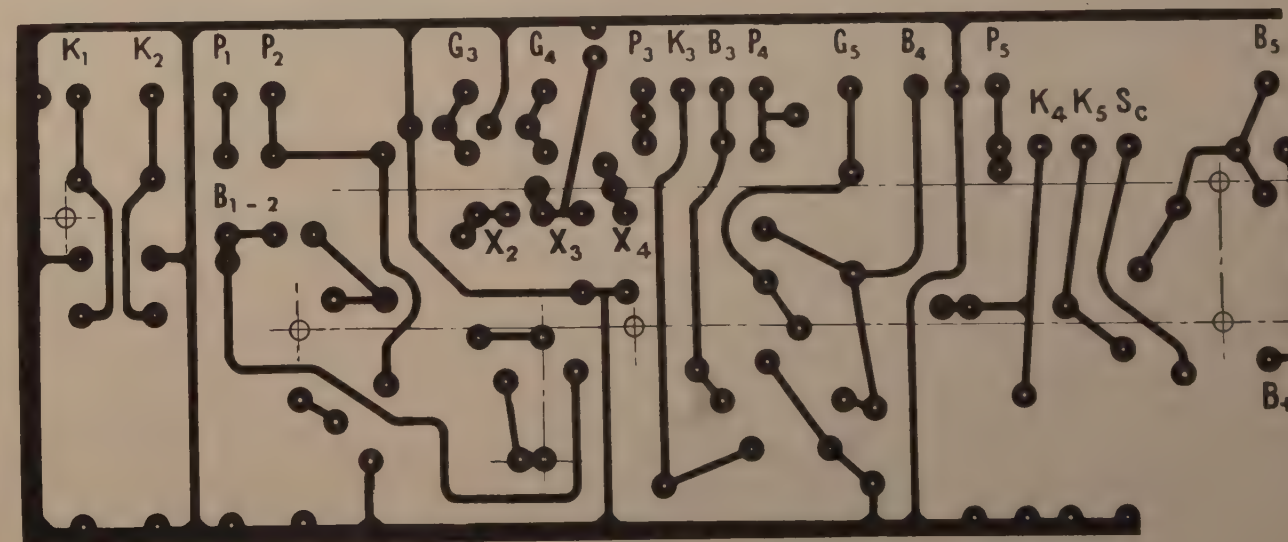


FIGURE 5. PRINTED CIRCUIT SHOWING TEST POINTS

done by checking with an ohmmeter the resistors of that stage. All ohmmeter checks should be made with the power off and the plug-in capacitor and vacuum tubes removed. If the resistors are correct, it can generally be assumed that a capacitor or capacitors associated with that

section of the circuit are defective. Test them by replacement.

This systematic checking of each resistor and capacitor in the defective stage will quickly identify the defective part.

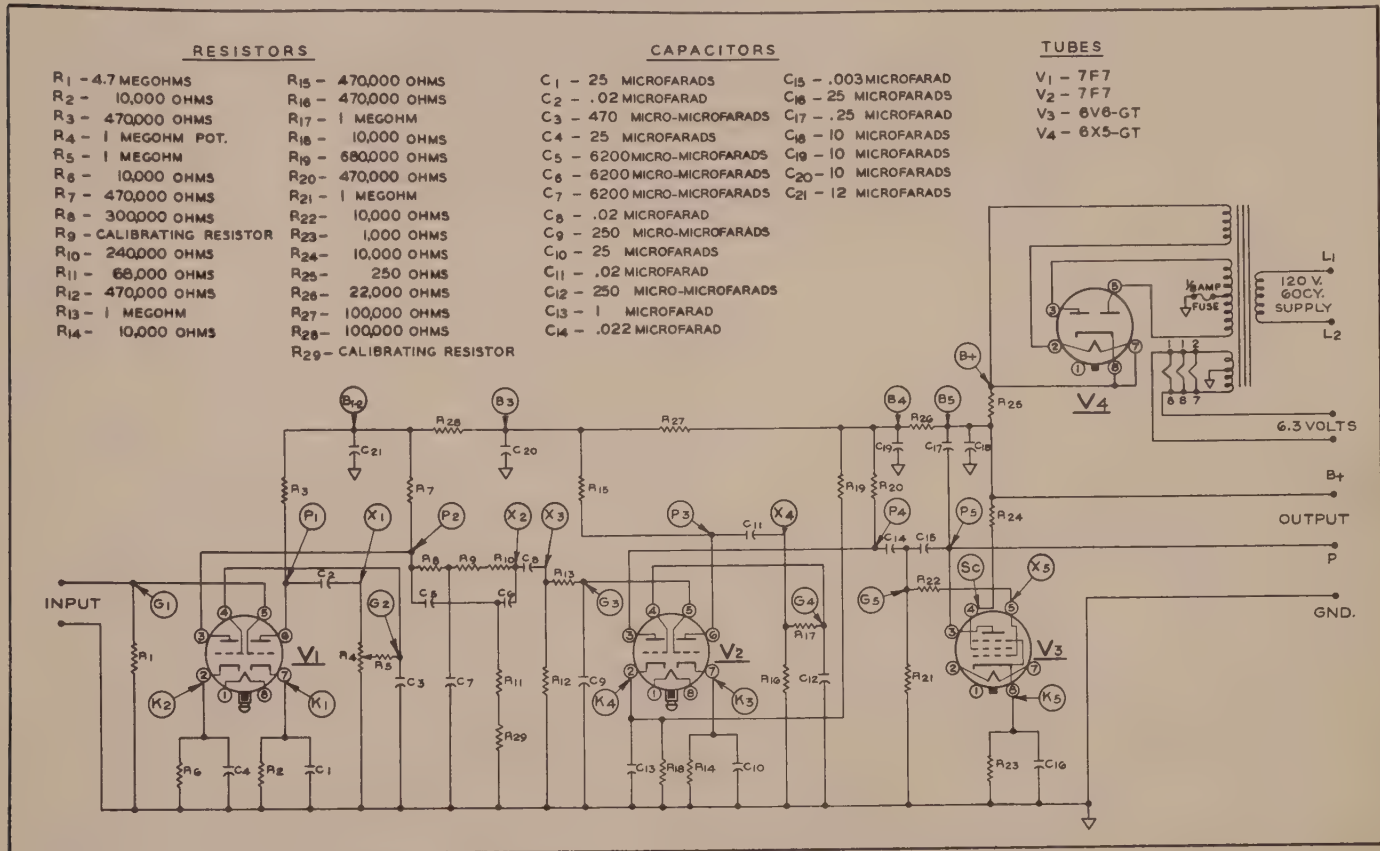


FIGURE 6. SCHEMATIC WIRING DIAGRAM SERIES C-1 AMPLIFIER

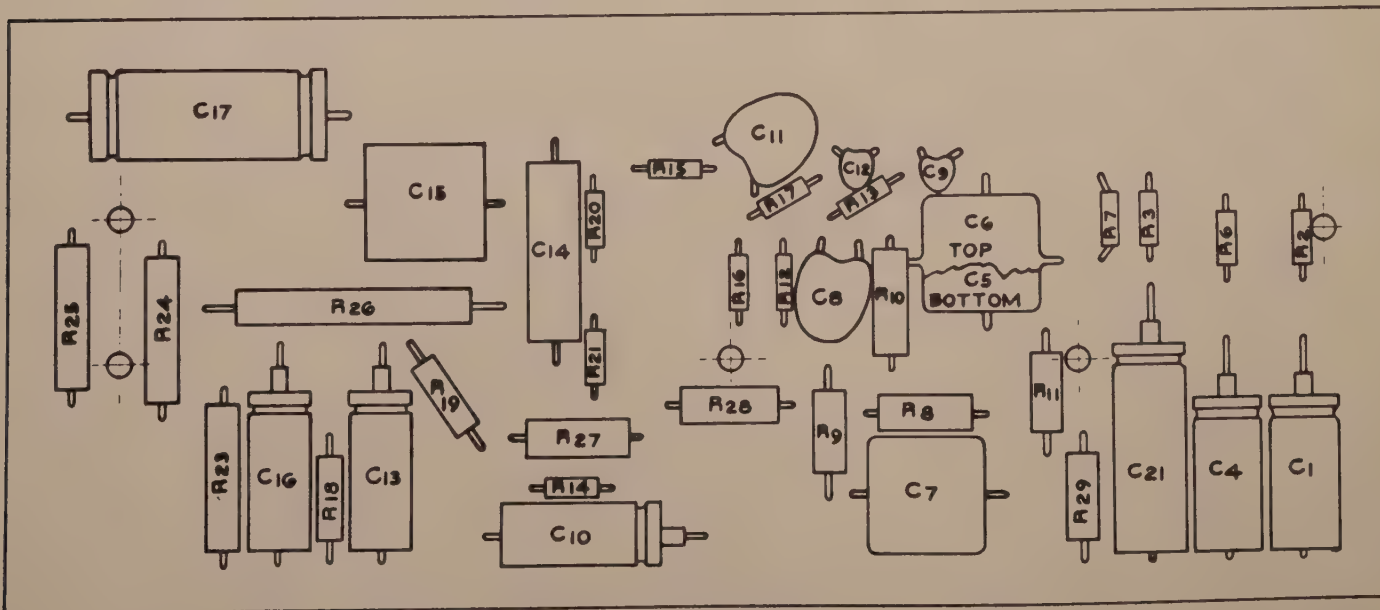


FIGURE 7. COMPONENT SIDE OF PRINTED CIRCUIT BOARD

INSTRUCTIONS P12500

(Issue No. 2 of Aug. 1953)

INSTALLATION & SERVICE OF THERMOCOUPLES, EXTENSION WIRE & PROTECTING TUBES

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PART I PYROMETER PRINCIPLES

A. THERMOCOUPLE PRINCIPLES

If the two junctions in a closed electric circuit made of two dissimilar conductors are at different temperatures, an electromotive force (emf) will be generated, proportional to that temperature difference. In the fundamental thermal circuit (See Fig. 1) the temperatures T_1 and T_2 differ, so an electromotive force develops between the dissimilar metals A and B. An instrument may be used to measure this emf between the pair of junctions. This is the basic circuit and principle of all thermoelectric thermometers.

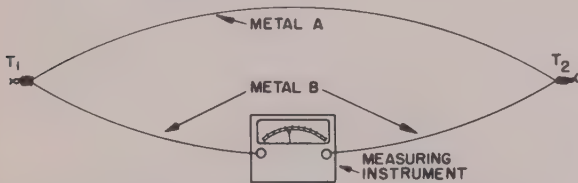


FIG. 1. THE FUNDAMENTAL THERMO-ELECTRIC PYROMETER CIRCUIT.

B. EXTENSION WIRE PRINCIPLES

It must not be overlooked that the measuring junction or "hot" junction is only one half the thermocouple and thus

the pyrometer is reading not the temperature of this measuring junction but the temperature difference between the measuring and reference junction. Therefore, variations in the reference junction affect the instrument reading no less than those in the measuring junction. In the early days the reference or cold end junction was held at constant temperatures by burying it deep in the ground, using a control temperature box and other devices. Today the cold junction temperature is allowed to vary, but mechanical or electrical compensation is introduced into the pyrometer reading. The connections between extension wires and the couple and instrument are also junctions in the pyrometer circuit, whose temperature may vary widely. To prevent introduction of extraneous emf's from such junctions, extension wire must be either of the same metals as the measuring junction itself, or of metals with the same thermoelectric properties. For economics sake, especially with platinum thermocouples, extension leads are made of inexpensive alloys having emf characteristics matching the couples with which they are used.

PART II INSTALLATION

A. GENERAL

Interior temperature of ovens, tanks, baths etc., may vary widely from point to point. Therefore of first importance is the location of the couple so that it acquires the temperature to be measured. A test to determine this correct installation point may be made with a portable thermocouple before the permanent installation is placed. Turbulence of the measured medium at the couple tip should be high if possible to increase heat transfer to the couple. Direct flame with its reducing atmosphere should be avoided. The space between furnace wall and protection tube and other adjacent holes should be cemented to prevent either cooling of the couple by entering cold air or over-heating of the terminal head by escaping hot gases. If possible, install the couple so that the hot end of the tube can be inspected from the furnace door. For temperatures above 1500°F., we recommend that couples and

tubes be vertically suspended thru the crown or roof of ovens or furnaces as bending of both metal and ceramic wells is likely at temperatures near their upper limits, if otherwise installed.

1. Thermocouple Installation (see drawings of typical installations).

The entire couple junction should be inserted at least 10 diameters of the protecting tube beyond the inside surface of the furnace or beneath the surface of a liquid or molten metal.

Thermocouple should be preheated before installation in a hot furnace to avoid breakage of the porcelain insulators due to thermal shock. A thermocouple which is to be permanently installed should be mounted firmly with proper support. It must be protected from mechanical injury and should not be subjected to severe jarring. Never locate a thermocouple in a furnace or oven where it will

be subjected to direct flame impingement. The life of the protecting tube will be materially shortened and the temperature readings will not be representative of the normal furnace atmosphere.

Once a thermocouple is installed in a furnace it should not be removed or disturbed. If it is desired to check the calibration of the couple, a second couple should be inserted in the furnace so that the tips touch each other. If a couple is removed from a furnace and used elsewhere, the depth of immersion may differ and the heated portion of the wire will be in a different temperature gradient, causing an error. It is better to obtain a new couple rather than transfer an old one to another application.

Couples used in liquids or in molten metals, pots, kettles, etc., are best mounted so that they may be conveniently withdrawn at any time for inspection or testing. Suspension of such couples by chains, pulleys, and counter balances is recommended so that they may be quickly removed while charging the pots. No metallic protecting tube will indefinitely resist the corrosive action of molten aluminum or aluminum alloys. Refractory tubes are too liable to breakage, on the other hand, to be practical. Many foundries follow the practice, therefore, of daily painting metallic tubes with a thick white wash solution. Paints of sodium silicate and silicon carbide mixtures are also used. If necessary tubes of the cold extension type as illustrated in Fig. 13 or the angle type Fig. 12 should be used so that the terminal head may be located in a cool accessible spot for testing and inspection of the couple and connection.

Distortion of couple junction by rolling, twisting or hammering will cause

calibration changes due to molecular rearrangement in the couple metal. The electrical welding process employed by The Bristol Company in making thermocouple junctions avoids mechanical working and substantially reduces this source of calibration error. Calibration is also affected by excess vibration, and the frequency and degree of heating and cooling.

2. Extension Wire Installation

Connect the extension wires to the thermocouple by means of the terminals provided, the other end of the extension going to the instrument binding posts. When connecting a thermocouple and extension to an instrument the polarity must be strictly observed i.e.; positive (+) to positive and negative (-) to negative. (See Figure 3).

CAUTION: Always use extension wires specifically designed for the kind of couple being used. Never use plain copper wires or extension wires intended for another kind of thermocouple.

For all permanent installations, we recommend that a covered terminal head be used with all extension wires contained in conduit, which connects directly into rotary switches, instrument cases and the thermocouple head. If flexibility is necessary use a flexible armored extension wire.

CAUTION: Extension wires should never be installed parallel to or crossing within 12 inches of an a-c power line and all conduit should be grounded to prevent induced currents. All splices in extension wires should be carefully soldered and carefully taped.

CONDUIT SIZE (INCHES)	APPROXIMATE NUMBER OF PLASTIC AND BRAID INSULATED DUPLEX EXTENSION WIRES ACCOMMODATED BY CONDUIT.				
	#8	#10	#12	#14	#16
1/2	1	1	1	2	4
3/4	2	2	3	4	6
1	3	4	5	6	9
1-1/4	6	7	8	10	20
1-1/2	9	12	13	15	26

FIG. 2. A GUIDE TO THE SIZE OF CONDUIT FOR EXTENSION WIRE.

THERMOCOUPLE		EXTENSION WIRE		COLOR CODE	
ISA CODE	FORMER CODE	CODE	MATERIAL	INDIVIDUAL	OVERALL
J	1C	JX	+ Iron - Constantan	white red	black
T	24B	TX	+ Copper - Constantan	blue red	black
K	25H	VX	+ Copper - Constantan	brown red	red
K	25H	KX	+ Chromel - Alumel	yellow red	yellow
S	27	SX	+ Copper - Special Alloy	black red	green
R	32	SX	+ Copper - Special Alloy	black red	green

FIG. 3. COLOR CODE OF EXTENSION WIRES

a. Installation Millivoltmeter Pyrometers. Millivoltmeter type pyrometers are calibrated for a definite external resistance (sometimes called C + L which is the total resistance of the thermocouple and extension wire. The external resistance is marked on the scale plate of the instrument. Standards for current models call for 2 ohms external resistance unless order specifies otherwise. Uncalibrated extension wire will result in an error of less than 1% on these instruments if extension lengths do not exceed 30 ft. of duplex no. 14 wire. Therefore, in most cases, uncalibrated extension can be used with all modern high resistance millivoltmeter pyrometers. Exceptions to this are when extension wires are long, in which case calibrating for a higher external resistance should be specified or when exceptional accuracy is required, in which case the extension wire should be calibrated to match the instrument. The internal resistance of the instrument is marked on the scale plate. This resistance is measured across the binding posts.

CAUTION: Never use an ohmmeter to measure the resistance of a millivoltmeter movement. Use a potentiometer type test set.

A high resistance millivoltmeter pyrometer has an internal resistance above 150 ohms. A low resistance instrument has an internal resistance of less than 50 ohms.

Any change in external resistance will cause a much more serious error in the

instrument having a low internal resistance than one with a high internal resistance. Changes in the line and couple resistance of as much as 2 or 3 ohms are not uncommon in practice and may be caused by oxidation of the thermocouple wires, poor contacts or connections, variable depth of immersion of the thermocouple, temperature variations in the extension wire and structural faults in the wire.

b. Installation Potentiometer Pyrometer. It is unnecessary to calibrate extension wire when used with a potentiometer type pyrometer. The reason for this is that when the instrument is at balance, the instrument draws no appreciable current and therefore produces no measurable voltage drop in the extension wires.

B. THERMOCOUPLE TYPES

Metals for thermocouples are selected to give the largest possible emf, which increases with an almost linear relationship to temperature, while possessing resistance to melting, corrosion and changes in emf characteristics during use. While platinum, which was used for most early couples, possesses all the above desirable qualities, its high cost makes very desirable the substitution of less expensive "base metal" thermocouples. Therefore in 1905 The Bristol Company developed the first practical base metal thermocouple. Since then many variations of base metal thermocouples have been developed and by continued research the number of base metal thermocouples now in use has been reduced to three.

1. The iron constantan, "J" couple with positive wire of iron and negative wire of constantan, an alloy of approximately 55% copper and 45% nickel is recommended for reducing atmospheres. The operating range for the J couple is 1600°F maximum for the largest wire size and lower for the smaller sizes. See Figure 4.

Before the standard J couple had been adopted by the pyrometer industry, The Bristol Company made thermocouples of pure iron and of constantan of slightly different emf characteristics, known as the "18B" curve" which can still be furnished on order in any type or form, as replacement for existing instruments.

2. The copper constantan couple (Bristol T Curve or the Adams Curve per NBS RP1080), with positive wire of copper and negative wire of constantan is recommended for use in mildly oxidizing and reducing atmospheres thru 650°F, applications where moisture is present and for low temperature work down to -300°F. This couple is recommended for temperatures below 400°F or 200°C because its emf curve is more linear than the J couple in this range.

3. The Chromel-Alumel Couple (Bristol K curve) with positive wire of chromel (an alloy of approximately 90% Ni and 10% Cr.) and the negative wire of alumel (an alloy of approximately 95% Ni, 5% Al., Mn and Si) is recommended for use in clean oxidizing atmospheres. Because it gives high emf temperature curves and its high nickel content provides oxidation resistance, the K couple is the most practical and widely used.

4. Platinum Thermocouples. Two types of noble metal couples are in use, first the LeChatelier, with negative wire of pure platinum and positive wire of 90% platinum and 10% rhodium (Bristol S Curve), second the "87-13 type thermocouple (Bristol R Curve). Because the 90-10 platinum rhodium-platinum couple is used in defining the international temperature scale and by the National Bureau of Standards, it is offered as the standard by The Bristol Company. However we can furnish the 87-13 type platinum couple on order.

C. THERMOCOUPLE INSULATION

Three kinds of insulation can be sup-

plied with Bristol Thermocouples, the asbestos, porcelain and glass fibre. Asbestos insulation is molded on bare wires. Porcelain insulation is recommended for use above 1600°C or 850°C as asbestos insulation becomes brittle above this temperature. Asbestos insulation is frequently preferred with angle type thermocouples for ease in replacement of elements which can be bent as required on the job. Glass fibre may be used up to 900°F.

D. FACTORS AFFECTING THERMOCOUPLE ACCURACY

1. Location - see general installation instructions and installation illustrations.

2. Conduction Error - Heat conduction away from the measuring junction along the protection tube and couple wires will cause serious errors in temperature reading unless the entire couple junction is inserted at least 10 diameters of the protection tube beyond the inside surface of the furnace or beneath the surface of a liquid or of molten metal. It may be concluded that immersion is sufficient to achieve this accuracy, if no noticeable change in temperature reading occurs upon withdrawing the couple 1 inch from its protection tube. With very high temperatures, to prevent couple melting, only partial immersion may be used. For examples see Fig. 13. Furnace temperature variations may thus be measured and even heat control thus accomplished, but obviously with partial immersion of the thermocouple, true temperatures are not obtained. Many suggested types of installation are shown further on in this book.

3. Corrosion & Poisoning. Accuracy of thermocouples will be rapidly and seriously destroyed by poisoning, alloying or contamination of the couple metal. See paragraph on corrosion and poisoning in section under factors affecting thermocouple life.

E. FACTORS AFFECTING THERMOCOUPLE LIFE

In general the following four factors affect the life of the thermocouple in the order given and should be so considered when selecting a couple.

1. Temperature. The following table gives a conservative guide to minimum and maximum temperature of the standard type couples.

TYPES OF THERMOCOUPLE	TEMPERATURE RANGES	
	°C	°F
Platinum-Platinum Rhodium S or R Curve #24 AWG (20 Mill)	0-1482	0-2700
Chromel-Alumel (K)		
#8 AWG	0-1262	0-2300
#14 AWG	0-1093	0-2000
#20 AWG	0-982	0-1800
Iron Constantan (J)		
#8 AWG	0-760	0-1400
#14 AWG	0-593	0-1100
#20 AWG	0-482	0-900
Copper-Constantan (T)		
#14 & #20 AWG	-183 to +345	-300 to +650

FIG. 4. MAXIMUM CONTINUOUS TEMPERATURE LIMITS (COUPLE IN WELL).

For temperatures above 2650°F or 1450°C the radiation type of thermocouple is recommended.

2. Corrosion and Poisoning. The oxidizing and reducing effects of air and of furnace atmosphere, corrosion by chemicals, fumes etc. are very common causes for couple failure. Should there be any question whether an atmosphere is oxidizing or reducing a simple test can be performed. See Part III Service.

a. Iron constantan (J) thermocouples should be used in a reducing atmosphere. The life of both the iron and constantan legs will remain substantially the same, except in oxidizing atmospheres. In this case the iron will deteriorate more rapidly than the constantan.

b. Copper constantan (T) thermocouples withstand oxidation in temperatures up to 650°F. Beyond this temperature the copper leg commences to oxidize rapidly.

c. Chromel-Alumel (K) thermocouples should be used in clean oxidizing atmospheres. Sulphur in an atmosphere will rapidly contaminate a chromel-alumel thermocouple causing calibration errors and rapid failure. Where it is known there is a high sulphur content such as found in burning Bunker C oil or natural gas, special protection wells or tubes should be ordered for the thermocouples. In using powdered coal as a source of heat for certain high temperature applications, the atmosphere may contain sulphur and carbon in their many states. Unless adequate protection is provided, the couple will undergo extremely rapid deterioration known as "green rot". Further, the protection tubes used for

chromel-alumel thermocouples should be clean and free of any traces of core sand, oil or other organic materials that form carbon and reducing agents at high temperatures. Where doubt exists concerning the cleanliness of such a tube it should be heated in a furnace at or near 1500°F for several hours to burn off any organic matter present. The choice of insulators used on chromel-alumel thermocouples may also affect the life of the thermocouple. Presence of the so called "alkaline earths" such as sodium and phosphorous would contaminate a chromel-alumel thermocouple, cause a calibration shift and shortened life. Insulators furnished by The Bristol Company are cleaned to remove contaminating matter.

d. Platinum Rhodium-Platinum (S or R) Thermocouples in general have a high resistance to oxidation and corrosion. However, hydrogen, carbon and many metal vapors found in furnace atmospheres will seriously contaminate a platinum rhodium platinum thermocouple. Therefore a gas tight, non-metallic protection tube should be used.

3. Couple Wire Size. Couples made of large wire, such as No. 8 to No. 14 resist corrosion far longer than the smaller sizes but the smaller sizes are more responsive to temperature changes. Therefore in choosing the wire size for a given thermocouple, a compromise between responsiveness and life of the couple must be made based upon the requirements of the particular application.

Platinum rhodium and platinum thermocouple wire comes only in the #24 AWG size. Other couple materials are available in several sizes.

4. Mechanical Damage. Distortion of couple junction by rolling twisting or hammering will cause calibration changes due to molecular rearrangement in the couple metal. Calibration is also affected by excess vibration and the frequency and degree of heating and cooling. Obviously, the only way that these conditions can be avoided is by the proper selection of couple location and protection tubes.

F. CALIBRATED THERMOCOUPLES

Any Bristol thermocouple can be supplied, at an extra charge, either with an individual calibration curve, made in Bristol's laboratory by precision comparison against National Bureau of Standards certified couples or can be supplied with a certificate of check by the National Bureau of Standards itself. In ordering such calibrated thermocouples, be sure to specify over what temperature range the greatest accuracy is desired. We recommend that all thermocouples to be used as standards or for checking work, be ordered with one of the two above calibration curves supplied.

NOTE: When ordering certified selected thermocouples your order must read 12" greater than the length you desire. (Applies only to base metal couples).

G. PROTECTING TUBES

Thermocouples must not be immersed, without the protection of a well or protecting tube, in fluids or gases of a

corrosive or erosive nature. The function of the protecting tube is to protect the couple wire against mechanical damage and corrosive or contaminating atmospheres. Protecting tube materials are chosen for their ability to withstand at high temperatures, mechanical shock and stress, sudden temperature changes, oxidation or reduction, chemical corrosion and metallic amalgamation, while at the same time providing high thermoconductivity and low porosity to gases. Since no one material possesses all these qualities it is necessary to choose a tube to suit the installation.

1. Metallic Tubes - A conservative guide for the maximum safe temperatures for various metal tubes or wells is given in Figure 5.

Metallic tubes are usually sufficient protection for base metal couples, although a single Mullite tube is frequently used with chromel-alumel couples between 2000 & 2400°F.

2. Ceramic tubes. Due to its tendency to contamination, the platinum couple cannot be used in metallic tubes but should be protected by a suitable gas tight refractory protection tube such as a mullite or fused quartz. As the refractory tubes are fragile, a secondary tube of metal or ceramic depending upon the temperature is often used outside this first or primary tube to provide mechanical protection.

TYPE OF TUBE	RECOMMENDED MAXIMUM TEMPERATURE	
	°C	°F
Seamless Steel	550	1000
Wrought iron	700	1300
Cast iron	700	1300
Chrome iron (28%)	1100	2000
Stainless steel (18% cr. -8% Ni.)	850	1600
Nichrome	1100	2000
Thermalloy (cast steel with 24 cr. 12 Ni)	1200	2200
Chromax (cast steel with 18 cr. 35 Ni)	1100	2000
Misco B (drilled steel 24 cr. 12 Ni)	1100	2000
Nickel	1100	2000
Inconel (79.5 Ni., 13 cr., 6 Fe)		
For Furnace	1260	2300
For lead bath	980	1800

FIG. 5. RECOMMENDED MAXIMUM OPERATING TEMPERATURES OF METAL PROTECTION TUBES.

PART III THERMOCOUPLE SERVICE

The accuracy of a thermocouple will depend on temperatures being measured, oxidation, contamination, the care with which a couple is made and the alloys used for the couple. As the accuracy of a thermocouple will become progressively less as the couple deteriorates it is advisable to test couples at intervals varying from once a week to once every three months, depending on the service.

Iron constantan couples change very little from time of installation to end of couple life. Chromel-Alumel couples change continuously with age.

A. TROUBLE SHOOTING PROCEDURE

One of the most frequent causes of pyrometer trouble is due to poor connections between thermocouples and instrument. When a pyrometer fails to indicate proper temperature first check connections between extension wires and instrument and between extension wires and couple. Quite frequently when first installing or replacing a couple or extension wire the connections at the couple are reversed and an error results.

1. **Resistance Check.** Most present day millivoltmeter instruments are high resistance movements. The external resistance on these movements is usually 2 ohms. Older type movements were of the low resistance type with an internal resistance of 100 ohms or less and usually have a calibrated extension wire with a resistance of 10 to 15 ohms.

Changes in the external resistance of as much as 2 or 3 ohms are not uncommon in practice and may be caused by oxidation of the thermocouple wire, poor connections, variable depth of immersion of the thermocouple, temperature variations in the extension wire and structural faults in the wire.

When making a resistance check disconnect extension wires from instrument. Hook up an ohmmeter across ends of extension wire. If ohmmeter reading is considerably higher than the external resistance value marked on scale plate of instrument, check resistance at the thermocouple itself. If resistance is high at couple the fault lies in the couple. If resistance is OK at couple but high at instrument end of extension wires the fault is in the extension wires.

CAUTION: Never use an ohmmeter to check the internal resistance of a Millivoltmeter type instrument. Use only a potentiometer type test set.

2. **Checking a couple in service.** This method is used only when a quick test is necessary and where accuracy is not important. It may be done in one of several ways.

a. Inserting test couple in a test hole near the permanent couples. It is important to duplicate the conditions of the permanent couple as closely as possible and the test couple should have the same type of protecting tube. Readings of the two couples may then be compared.

b. Inserting test couple in same protecting tube as permanent couple if there is room and comparing their readings.

c. Alternately inserting the test couple and permanent couple in same hole. Satisfactory results can only be obtained by this method when the furnace temperature is reasonably constant.

3. **Check by use of Muffle Furnace.** One of the most desirable methods of checking a thermocouple is by means of a small muffle furnace. Remove couple to be checked from its protecting tube and tie the hot junction to the hot junction of a test couple with asbestos string. Insert couples in the furnace and bring furnace up to a constant temperature within the temperature range in which the couple is intended to operate. When the two couples have reached a constant temperature the emf of each may be read on a test instrument connected to the couples thru a switch which permits couple to be alternately connected to test instrument.

4. **Check by use of a Metal Bath.** This method is satisfactory for many industrial users but is not as accurate as the muffle furnace method. Equipment includes an iron pot filled with lead or tin, covered with graphite and heated by means of a gas or electric furnace. The thermocouples to be tested, including the standard, are inserted in an iron protecting tube closed at one end, and immersed in the molten bath. Read-

ings are taken when a temperature equilibrium is reached. The practical temperature range is between 600 and 1800°F. Couples should be immersed in the bath to a depth of at least 12 inches.

5. Corrosion and Poisoning. The oxidizing and reducing effects of air and of furnace atmosphere, corrosion by chemicals, fumes etc. are very common causes for couple failure. Should there be any question whether an atmosphere is oxidizing or reducing, a simple test can be performed. Cupric oxide may be used as an indicator, provided it will not react dangerously with the application. If the cupric oxide remains black, the atmosphere in which it was placed is oxidizing. If it turns to some shade of red, the atmosphere is reducing. When the cupric oxide is placed in a protecting tube with a thermocouple and allowed to operate at high temperature, reduction of the cupric oxide may produce molten copper that will cause the thermocouple to stick to the protection tube when the assembly is withdrawn and

allowed to cool. This would indicate that reducing gases have leaked thru the tube.

6. The following is a list of desirable checking equipment.

1. Potentiometer Type Test Set.
2. Ohmmeter.
3. Standard platinum couple with protecting tube.
4. Standard base metal thermocouple.
5. Electric muffle furnace or metal bath.
6. Temperature-Millivolt equivalent tables. (Included with all pyrometers).

B. CORRESPONDENCE AND INFORMATION

If difficulties arise or information is needed, write to the nearest Bristol Company branch office stating the nature of the problem and all pertinent data. For all replacements, supplies and information, it is essential to give the model and serial number of the instrument.

The Bristol Company
Waterbury 20, Connecticut

Printed in U.S.A.

SUGGESTED METHODS OF THERMOCOUPLE INSTALLATION

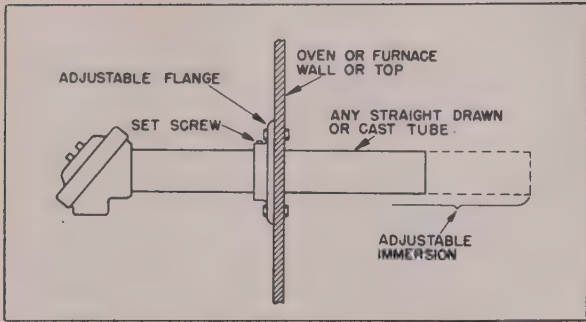


FIG. 6. SHEET METAL OVEN, FURNACE FOR DUCT WALL WITH COUPLE MOUNTED WITH ADJUSTABLE FLANGE.

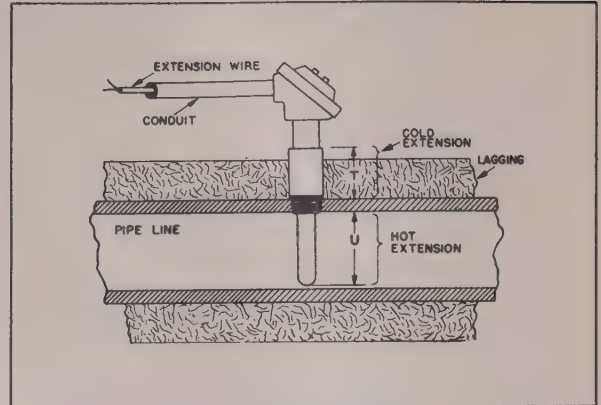


FIG. 9. HIGH PRESSURE STEAM, OIL, GAS, ETC., PIPE LINE WITH THERMOCOUPLE PROVIDED WITH EXTENSION "F" TO PASS THROUGH LAGGING.

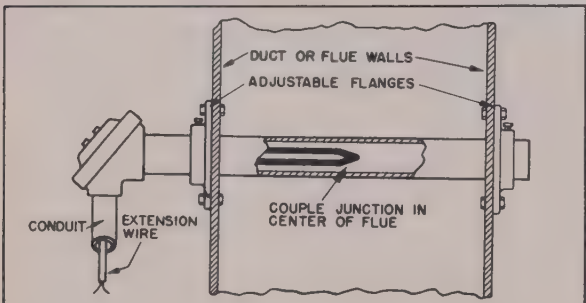


FIG. 7. BOILER BREECHING, COAL DRYER FLUE OR DUCT WITH COUPLE USING ANY STRAIGHT WELL MOUNTED FROM SIDE TO SIDE OF DUCT WITH TWO ADJUSTABLE FLANGES.

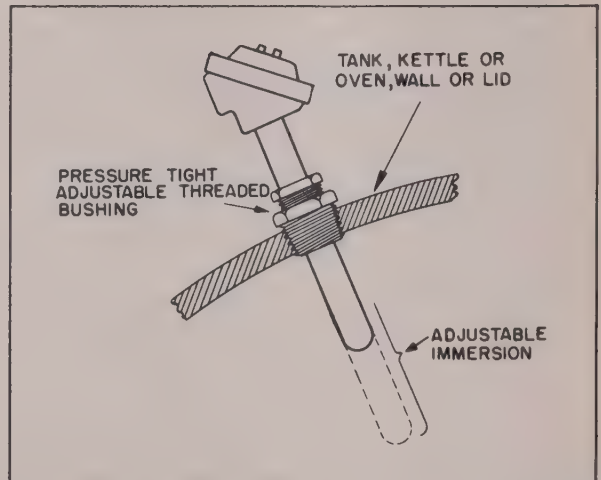


FIG. 10. TANK, KETTLE, PIPE OR OVEN WITH THERMOCOUPLE MOUNTED WITH A PRESSURE AND GAS TIGHT ADJUSTABLE THREADED BUSHING.

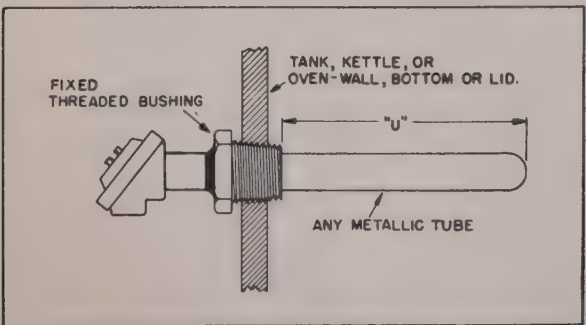


FIG. 8. TANK, KETTLE OR OVEN WITH ANY METALLIC WELL MOUNTED BY A FIXED THREADED BUSHING.

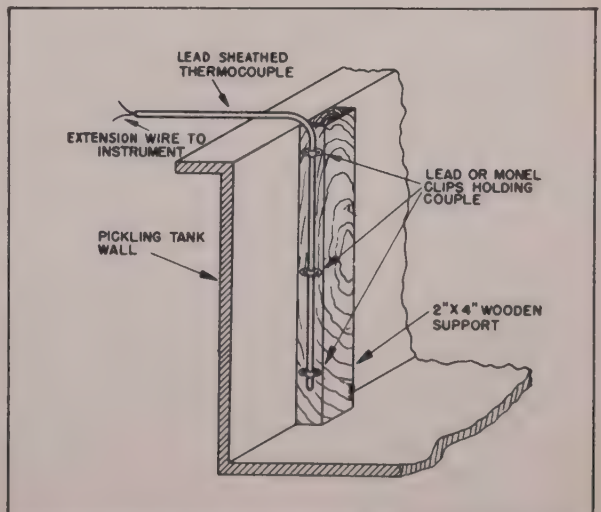


FIG. 11. PICKLING, PLATING OR ACID TANK SHOWING SUGGESTED MEANS OF MOUNTING LEAD SHEATHED REPAIRABLE THERMOCOUPLE.

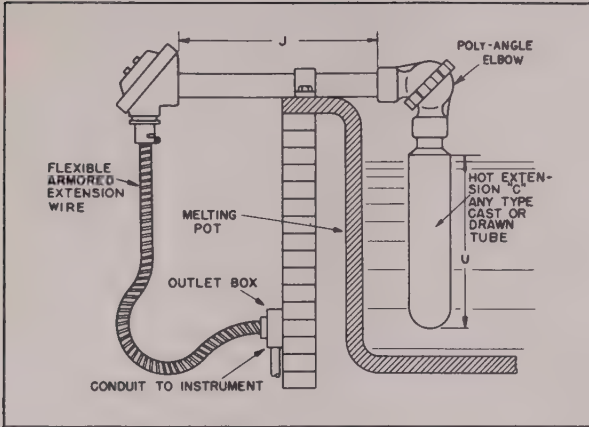


FIG. 12. POT OR KETTLE FOR ALUMINUM, DIECAST METAL, STEREOTYPE, GALVANIZING, MOLTEN SALT BATHS WITH ANGLE TYPE COUPLE. FLEXIBLE ARMORED EXTENSION WIRE PERMITS REMOVAL OF COUPLE FOR CHARGING POT, COUPLE INSPECTION AND WHITEWASHING OF WELL.

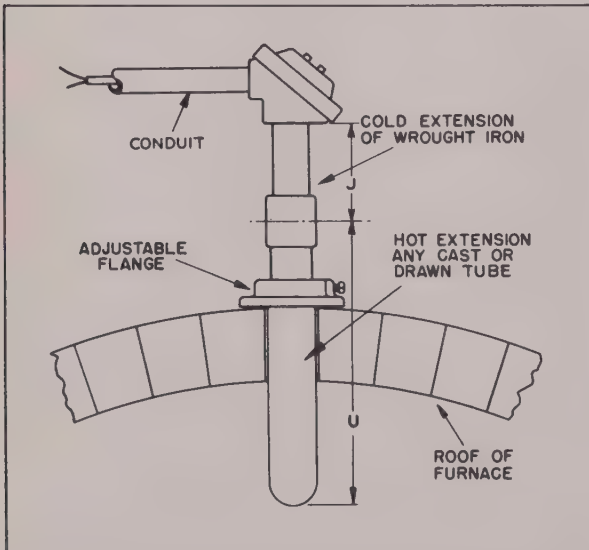


FIG. 13. MUFFLE, HEAT TREATING OR HARDENING FURNACE WITH HOT AND COLD EXTENSION TYPE COUPLE MOUNTED WITH AN ADJUSTABLE FLANGE.

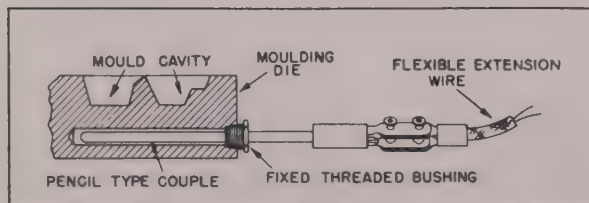


FIG. 16. MOULDING TEMPERATURES OF DIES IN PLATEN PRESS PLASTIC MOULDING TAKEN WITH PENCIL TYPE COUPLE MOUNTED WITH FIXED THREADED BUSHING.

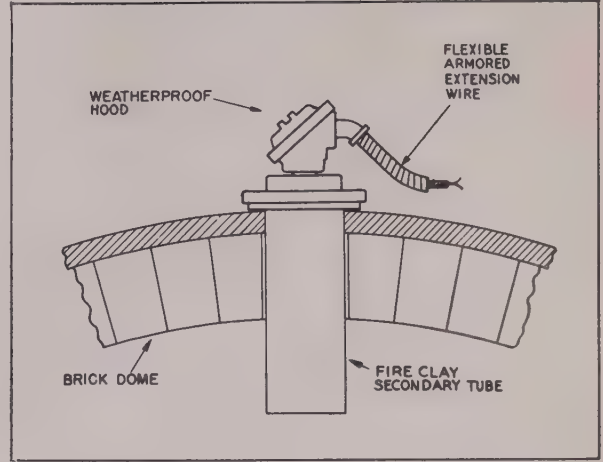


FIG. 14. BRICK, PORCELAIN, TILE, KILN, ETC., ROOF OR DOME WITH PLATINUM COUPLE WITH HEAD SUITABLE FOR OUT DOOR INSTALLATION.

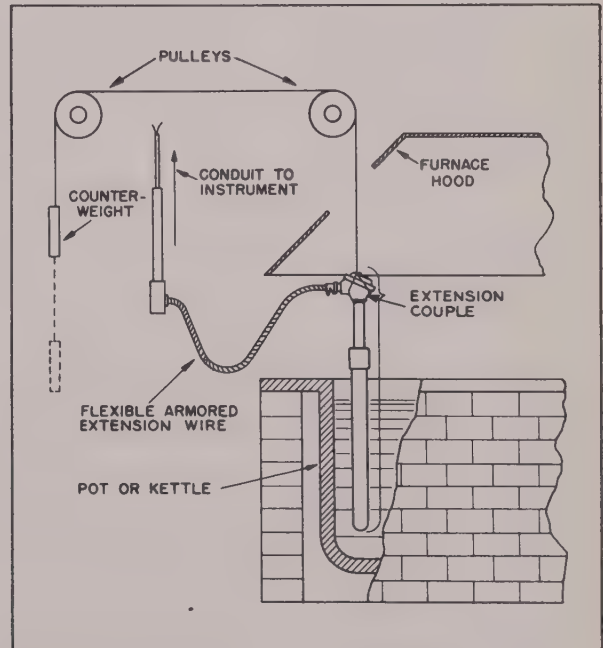


FIG. 15. ALUMINUM, DIECASTING, GALVANIZING, ETC., KETTLE OR POT, WITH HOT & COLD EXTENSION TYPE COUPLE SUSPENDED BY PULLEYS AND COUNTER-WEIGHT, PERMITTING CONVENIENT WITHDRAWAL BETWEEN MELTS, FOR WHITEWASHING, INSPECTION, ETC.

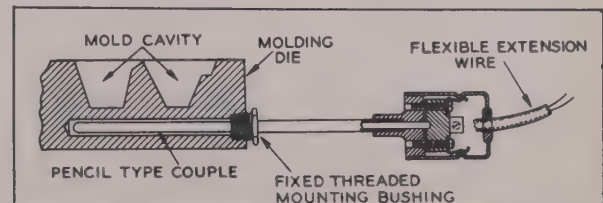


FIG. 17. MOULDING TEMPERATURES OF DIES IN PLATEN PRESS PLASTIC MOULDING TAKEN WITH PENCIL TYPE COUPLE MOUNTED WITH FIXED THREADED BUSHING.

INSTRUCTION NO. P12514

THERMOCOUPLE CALIBRATION DATA

Note: These data are based on the tables of NBS Research Paper 2415 and NBS Circular 508, as adopted by the Scientific Apparatus Makers Association and the Instrument Society of America.

Iron-Constantan Thermocouples, Type J	Page 2

Copper-Constantan Thermocouples, Type T	3

Chromel-Alumel Thermocouples, Type K (25H)	4, 5

Platinum-Platinum, 10% Rhodium Thermocouples, Type S	6, 7

Platinum-Platinum, 13% Rhodium Thermocouples, Type R	8, 9

Iron-Constantan Thermocouples, Type Y (RP1080)	10



°F

IRON-CONSTANTAN THERMOCOUPLES

Degrees Fahrenheit (Int. 1948) Cold End at 75° F (EMF at 32° F = -1.22 mv)

EMF IN ABSOLUTE MILLIVOLTS																					
°F.	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60	-65	-70	-75	-80	-85	-90	-95	°F.
-300	-8.74	-8.81	-8.88	-8.95	-9.01	-7.47	-7.57	-7.66	-7.75	-7.84	-7.93	-8.02	-8.11	-8.19	-8.28	-8.36	-8.44	-8.52	-8.60	-8.67	-300
-200	-6.98	-7.08	-7.18	-7.28	-7.38	-5.31	-5.43	-5.55	-5.66	-5.78	-5.90	-6.01	-6.12	-6.23	-6.34	-6.45	-6.56	-6.66	-6.77	-6.87	-200
-100	-4.71	-4.83	-4.95	-5.07	-5.19	-2.78	-2.92	-3.05	-3.18	-3.31	-3.44	-3.57	-3.70	-3.83	-3.96	-4.08	-4.21	-4.34	-4.46	-4.58	-100
0	-2.11	-2.24	-2.38	-2.51	-2.65																0
°F.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°F.
0	-2.11	-1.97	-1.83	-1.70	-1.56	-1.42	-1.28	-1.14	-1.00	-0.86	-0.72	-0.57	-0.43	-0.29	-0.15	0.00	0.14	0.29	0.43	0.58	0
100	0.72	0.87	1.01	1.16	1.30	1.45	1.60	1.75	1.89	2.04	2.19	2.34	2.49	2.64	2.79	2.94	3.09	3.24	3.39	3.54	100
200	3.69	3.84	3.99	4.14	4.29	4.44	4.59	4.74	4.89	5.05	5.20	5.35	5.50	5.65	5.81	5.96	6.11	6.26	6.42	6.57	200
300	6.72	6.88	7.03	7.18	7.34	7.49	7.65	7.80	7.95	8.11	8.26	8.42	8.57	8.73	8.88	9.03	9.19	9.34	9.50	9.65	300
400	9.81	9.96	10.12	10.27	10.43	10.58	10.74	10.89	11.04	11.20	11.35	11.51	11.66	11.82	11.97	12.12	12.28	12.43	12.59	12.74	400
500	12.90	13.05	13.20	13.36	13.51	13.66	13.82	13.97	14.12	14.28	14.43	14.58	14.74	14.89	15.04	15.20	15.35	15.50	15.66	15.81	500
600	15.96	16.12	16.27	16.42	16.58	16.73	16.89	17.04	17.19	17.35	17.50	17.65	17.81	17.96	18.12	18.27	18.42	18.58	18.73	18.88	600
700	19.04	19.19	19.34	19.50	19.65	19.80	19.96	20.11	20.26	20.42	20.57	20.72	20.88	21.03	21.18	21.33	21.49	21.64	21.79	21.95	700
800	22.10	22.25	22.41	22.56	22.71	22.87	23.02	23.17	23.33	23.48	23.63	23.79	23.94	24.10	24.25	24.40	24.56	24.71	24.87	25.02	800
900	25.18	25.33	25.48	25.64	25.80	25.95	26.11	26.26	26.42	26.58	26.73	26.89	27.04	27.20	27.36	27.52	27.67	27.83	27.99	28.15	900
1000	28.30	28.46	28.62	28.78	28.94	29.10	29.26	29.42	29.58	29.74	29.90	30.06	30.22	30.38	30.54	30.70	30.86	31.02	31.18	31.34	1000
1100	31.50	31.67	31.83	31.99	32.15	32.32	32.48	32.64	32.81	32.97	33.14	33.30	33.46	33.63	33.79	33.96	34.13	34.29	34.46	34.62	1100
1200	34.79	34.96	35.13	35.30	35.47	35.64	35.80	35.98	36.14	36.32	36.49	36.66	36.83	37.00	37.17	37.35	37.52	37.69	37.86	38.04	1200
1300	38.21	38.39	38.56	38.74	38.91	39.09	39.26	39.44	39.61	39.79	39.97	40.14	40.32	40.50	40.68	40.85	41.03	41.21	41.39	41.56	1300
1400	41.74	41.92	42.10	42.28	42.46	42.63	42.81	42.99	43.17	43.35	43.53	43.71	43.88	44.06	44.24	44.42	44.60	44.78	44.96	45.13	1400
1500	45.31	45.49	45.67	45.85	46.02	46.20	46.38	46.56	46.73	46.91	47.09	47.26	47.44	47.61	47.79	47.96	48.14	48.31	48.48	48.66	1500
1600	48.83																				1600

THERMOCOUPLE CALIBRATION DATA

°C

IRON-CONSTANTAN THERMOCOUPLES

Degrees Celsius (Centigrade, Int. 1948) Cold End at 25° C (EMF at 0° C = -1.28 mv)

EMF IN ABSOLUTE MILLIVOLTS																					
° C.	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60	-65	-70	-75	-80	-85	-90	-95	° C.
-100	-5.91	-6.11	-6.31	-6.51	-6.70	-6.89	-7.08	-7.26	-7.44	-7.61	-7.78	-7.94	-8.10	-8.25	-8.40	-8.55	-8.68	-8.82	-8.94	-9.06	-100
0	-1.28	-1.53	-1.78	-2.03	-2.28	-2.52	-2.76	-3.00	-3.24	-3.48	-3.71	-3.94	-4.17	-4.40	-4.62	-4.84	-5.06	-5.28	-5.49	-5.70	0
° C.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	° C.
0	-1.28	-1.03	-0.78	-0.52	-0.26	0.00	0.26	0.52	0.78	1.04	1.30	1.57	1.83	2.10	2.37	2.64	2.91	3.18	3.45	3.72	0
100	3.99	4.26	4.53	4.80	5.08	5.35	5.62	5.90	6.17	6.45	6.72	7.00	7.28	7.56	7.83	8.11	8.39	8.67	8.94	9.22	100
200	9.50	9.78	10.06	10.34	10.61	10.89	11.17	11.45	11.73	12.00	12.28	12.56	12.84	13.11	13.39	13.66	13.94	14.22	14.49	14.77	200
300	15.05	15.32	15.60	15.87	16.15	16.43	16.70	16.98	17.26	17.53	17.81	18.09	18.36	18.64	18.92	19.19	19.47	19.74	20.02	20.29	300
400	20.57	20.85	21.12	21.40	21.67	21.95	22.22	22.50	22.78	23.05	23.33	23.60	23.88	24.16	24.44	24.71	24.99	25.27	25.55	25.83	400
500	26.11	26.39	26.67	26.95	27.24	27.52	27.80	28.09	28.37	28.66	28.94	29.23	29.52	29.80	30.09	30.38	30.67	30.96	31.25	31.54	500
600	31.83	32.13	32.42	32.71	33.01	33.30	33.60	33.90	34.20	34.50	34.80	35.10	35.41	35.71	36.02	36.32	36.63	36.94	37.25	37.56	600
700	37.87	38.19	38.50	38.82	39.13	39.45	39.77	40.08	40.40	40.72	41.04	41.36	41.68	42.00	42.32	42.64	42.97	43.29	43.61	43.93	700
800	44.25	44.57	44.90	45.22	45.54	45.86	46.18	46.50	46.81	47.13	47.45	47.76	48.08	48.39	48.70						800



T
(24B) °F

COPPER-CONSTANTAN THERMOCOUPLES

Degrees Fahrenheit (Int. 1948) Cold End at 75° F (EMF at 32° F = -0.944 mv)

EMF IN ABSOLUTE MILLIVOLTS																				
°F.	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60	-65	-70	-75	-80	-85	-90	-95
-300	-6.228	-6.276	-6.323	-6.370	-6.417	-6.464	-6.511	-6.558	-6.605	-6.652	-6.699	-6.746	-6.793	-6.840	-6.887	-6.934	-6.981	-7.028	-7.075	-7.122
-200	-5.055	-5.123	-5.190	-5.258	-5.326	-5.394	-5.462	-5.530	-5.598	-5.666	-5.734	-5.802	-5.870	-5.938	-6.006	-6.074	-6.142	-6.210	-6.278	-6.346
-100	-3.503	-3.589	-3.674	-3.758	-3.841	-3.924	-4.006	-4.087	-4.167	-4.245	-4.324	-4.401	-4.477	-4.553	-4.628	-4.701	-4.773	-4.845	-4.916	-4.986
0	-1.614	-1.715	-1.816	-1.917	-2.016	-2.115	-2.214	-2.311	-2.407	-2.503	-2.598	-2.692	-2.786	-2.878	-2.970	-3.061	-3.151	-3.240	-3.329	-3.416
°F.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
0	-1.614	-1.511	-1.407	-1.303	-1.198	-1.093	-0.986	-0.880	-0.773	-0.664	-0.555	-0.445	-0.335	-0.224	-0.112	0.000	0.113	0.227	0.342	0.457
100	0.573	0.689	0.807	0.925	1.043	1.163	1.282	1.402	1.523	1.645	1.767	1.891	2.014	2.138	2.263	2.388	2.514	2.640	2.768	2.895
200	3.023	3.152	3.281	3.411	3.542	3.673	3.805	3.936	4.070	4.203	4.336	4.471	4.606	4.741	4.877	5.013	5.150	5.288	5.426	5.564
300	5.703	5.842	5.982	6.122	6.264	6.405	6.547	6.689	6.832	6.974	7.120	7.263	7.408	7.553	7.698	7.844	7.991	8.138	8.285	8.432
400	8.581	8.730	8.879	9.029	9.179	9.329	9.479	9.630	9.782	9.934	10.086	10.239	10.392	10.546	10.699	10.853	11.009	11.164	11.319	11.474
500	11.631	11.788	11.944	12.102	12.259	12.418	12.576	12.734	12.894	13.053	13.213	13.373	13.533	13.693	13.855	14.017	14.178	14.340	14.503	14.666
600	14.829	14.993	15.157	15.320	15.485	15.649	15.814	15.980	16.145	16.311	16.477	16.644	16.810	16.977	17.145	17.313	17.481	17.649	17.817	17.986
700	18.156	18.325	18.495	18.664	18.835	19.005	19.176	19.347	19.519	19.690	19.861									

T
(24B) °C

COPPER-CONSTANTAN THERMOCOUPLES

Degrees Celsius (Cenigrade, Int. 1948) Cold End at 25° C (EMF at 0° C = -0.990 mv)

EMF IN ABSOLUTE MILLIVOLTS																				
°C.	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60	-65	-70	-75	-80	-85	-90	-95
-100	-4.339	-4.478	-4.614	-4.747	-4.877	-5.004	-5.128	-5.249	-5.367	-5.482	-5.593	-5.702	-5.807	-5.909	-6.008	-6.103	-6.195	-6.284	-6.369	-6.452
0	-0.990	-1.181	-1.370	-1.557	-1.741	-1.923	-2.102	-2.279	-2.453	-2.625	-2.794	-2.961	-3.125	-3.286	-3.445	-3.601	-3.754	-3.904	-4.052	-4.197
°C.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
0	-0.990	-0.797	-0.601	-0.403	-0.203	0.000	0.204	0.411	0.620	0.831	1.045	1.260	1.477	1.697	1.918	2.142	2.367	2.594	2.823	3.054
100	3.287	3.522	3.759	3.997	4.237	4.479	4.722	4.967	5.214	5.463	5.713	5.964	6.218	6.472	6.729	6.988	7.246	7.507	7.769	8.033
200	8.298	8.565	8.833	9.103	9.373	9.645	9.919	10.193	10.469	10.745	11.025	11.304	11.585	11.867	12.150	12.435	12.720	13.007	13.295	13.583
300	13.874	14.165	14.457	14.750	15.045	15.340	15.636	15.934	16.232	16.531	16.831	17.133	17.435	17.737	18.042	18.347	18.652	18.959	19.267	19.575
400	19.884																			



(25H) °F



(25H)

CHROMEL-ALUMEL THERMOCOUPLES

Degrees Fahrenheit (Int. 1948) Cold End at 75° F (EMF at 32° F = -0.95 mv)

THERMOCOUPLE CALIBRATION DATA

EMF IN ABSOLUTE MILLIVOLTS																					
°F.	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60	-65	-70	-75	-80	-85	-90	-95	°F.
-300	-6.46	-6.50	-6.55	-5.46	-5.53	-5.59	-5.66	-5.72	-5.79	-5.85	-5.91	-5.97	-6.03	-6.09	-6.15	-6.20	-6.25	-6.31	-6.36	-6.41	-300
-200	-5.24	-5.31	-5.39	-3.87	-3.96	-4.05	-4.14	-4.22	-4.31	-4.39	-4.47	-4.55	-4.64	-4.71	-4.79	-4.87	-4.95	-5.02	-5.10	-5.17	-200
-100	-3.60	-3.69	-3.78	-1.94	-2.05	-2.15	-2.25	-2.35	-2.45	-2.55	-2.65	-2.75	-2.85	-2.94	-3.04	-3.13	-3.23	-3.32	-3.42	-3.51	-100
0	-1.63	-1.74	-1.84																		0
°F.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°F.
0	-1.63	-1.53	-1.42	-1.32	-1.21	-1.10	-0.99	-0.88	-0.77	-0.66	-0.55	-0.44	-0.33	-0.22	-0.11	0.00	0.11	0.23	0.34	0.45	0
100	0.57	0.68	0.79	0.91	1.02	1.14	1.25	1.37	1.48	1.60	1.71	1.83	1.94	2.06	2.17	2.29	2.41	2.52	2.64	2.75	100
200	2.87	2.99	3.10	3.22	3.33	3.45	3.56	3.68	3.79	3.91	4.02	4.13	4.25	4.36	4.47	4.58	4.70	4.81	4.92	5.03	200
300	5.14	5.25	5.36	5.47	5.58	5.70	5.81	5.92	6.03	6.14	6.25	6.36	6.47	6.58	6.69	6.80	6.92	7.03	7.14	7.25	300
400	7.36	7.47	7.59	7.70	7.81	7.92	8.03	8.14	8.26	8.37	8.48	8.59	8.71	8.82	8.93	9.05	9.16	9.27	9.39	9.50	400
500	9.62	9.73	9.84	9.96	10.07	10.18	10.30	10.41	10.53	10.64	10.76	10.87	10.99	11.10	11.22	11.33	11.45	11.56	11.68	11.79	500
600	11.91	12.02	12.14	12.25	12.37	12.49	12.60	12.72	12.83	12.95	13.07	13.18	13.30	13.41	13.53	13.65	13.76	13.88	14.00	14.11	600
700	14.23	14.35	14.46	14.58	14.70	14.81	14.93	15.05	15.17	15.28	15.40	15.52	15.64	15.75	15.87	15.99	16.11	16.22	16.34	16.46	700
800	16.58	16.69	16.81	16.93	17.05	17.16	17.28	17.40	17.52	17.63	17.75	17.87	17.99	18.11	18.23	18.34	18.46	18.58	18.70	18.82	800
900	18.94	19.06	19.18	19.29	19.41	19.53	19.65	19.77	19.89	20.00	20.12	20.24	20.36	20.48	20.59	20.71	20.83	20.95	21.07	21.19	900
1000	21.31	21.42	21.54	21.66	21.78	21.90	22.02	22.13	22.25	22.37	22.49	22.61	22.73	22.85	22.96	23.08	23.20	23.32	23.44	23.56	1000
1100	23.68	23.79	23.91	24.03	24.15	24.27	24.39	24.51	24.62	24.74	24.86	24.98	25.10	25.21	25.33	25.45	25.57	25.68	25.80	25.92	1100
1200	26.03	26.15	26.27	26.39	26.50	26.62	26.74	26.85	26.97	27.09	27.20	27.32	27.44	27.55	27.67	27.79	27.91	28.02	28.14	28.26	1200
1300	28.37	28.49	28.61	28.72	28.84	28.96	29.07	29.19	29.30	29.42	29.54	29.65	29.77	29.88	30.00	30.12	30.23	30.35	30.47	30.58	1300
1400	30.70	30.81	30.93	31.04	31.16	31.27	31.39	31.50	31.62	31.73	31.85	31.96	32.07	32.19	32.30	32.42	32.53	32.64	32.76	32.87	1400
1500	32.98	33.10	33.21	33.33	33.44	33.55	33.67	33.78	33.89	34.01	34.12	34.23	34.34	34.46	34.57	34.68	34.80	34.91	35.02	35.13	1500
1600	35.24	35.36	35.47	35.58	35.69	35.81	35.92	36.03	36.14	36.25	36.36	36.48	36.59	36.70	36.81	36.92	37.03	37.14	37.25	37.37	1600
1700	37.48	37.59	37.70	37.81	37.92	38.03	38.14	38.25	38.36	38.47	38.58	38.69	38.80	38.91	39.01	39.12	39.23	39.34	39.45	39.56	1700
1800	39.67	39.78	39.89	40.00	40.10	40.21	40.32	40.43	40.54	40.65	40.75	40.86	40.97	41.08	41.19	41.29	41.40	41.51	41.62	41.72	1800
1900	41.83	41.94	42.04	42.15	42.26	42.36	42.47	42.58	42.68	42.79	42.90	43.00	43.11	43.22	43.32	43.43	43.54	43.64	43.75	43.85	1900
2000	43.96	44.06	44.17	44.27	44.38	44.48	44.59	44.69	44.80	44.90	45.01	45.11	45.22	45.32	45.43	45.53	45.63	45.74	45.84	45.95	2000
2100	46.05	46.15	46.26	46.36	46.46	46.57	46.67	46.77	46.87	46.98	47.08	47.18	47.28	47.39	47.49	47.59	47.69	47.79	47.90	48.00	2100
2200	48.10	48.20	48.30	48.40	48.50	48.60	48.70	48.81	48.91	49.01	49.11	49.21	49.31	49.41	49.51	49.61	49.70	49.80	49.90	50.00	2200
2300	50.10	50.20	50.30	50.40	50.50	50.59	50.69	50.79	50.89	50.99	51.08	51.18	51.28	51.38	51.47	51.57	51.67	51.77	51.86	51.96	2300
2400	52.06	52.15	52.25	52.35	52.44	52.54	52.64	52.73	52.83	52.92	53.02	53.11	53.21	53.30	53.40	53.49	53.59	53.68	53.78	53.87	2400
2500	53.97																				2500



(25H) °C

CHROMEL-ALUMEL THERMOCOUPLES

Degrees Celsius (Centigrade, Int. 1948) Cold End at 25° C (EMF at 0° C = -1.00 mv)

THERMOCOUPLE CALIBRATION DATA

K

(25H)

EMF IN ABSOLUTE MILLIVOLTS																		
°C.	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60	-65	-70	-75	-80	-85
-200	-6.75																	
-100	-4.49	-4.64	-4.78	-4.92	-5.06	-5.19	-5.32	-5.45	-5.58	-5.70	-5.81	-5.92	-6.03	-6.14	-6.24	-6.34	-6.43	-6.52
0	-1.00	-1.19	-1.39	-1.58	-1.77	-1.95	-2.14	-2.32	-2.50	-2.68	-2.86	-3.03	-3.20	-3.37	-3.54	-3.71	-3.87	-4.03
°C.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
0	-1.00	-0.80	-0.60	-0.40	-0.20	0.00	0.20	0.40	0.61	0.81	1.02	1.23	1.43	1.64	1.85	2.05	2.26	2.47
100	3.10	3.31	3.51	3.72	3.92	4.13	4.33	4.53	4.73	4.93	5.13	5.33	5.53	5.73	5.93	6.13	6.33	6.53
200	7.13	7.33	7.54	7.74	7.94	8.14	8.34	8.54	8.75	8.95	9.16	9.36	9.57	9.77	9.98	10.18	10.39	10.59
300	11.21	11.42	11.63	11.83	12.04	12.25	12.46	12.67	12.88	13.09	13.29	13.50	13.71	13.92	14.13	14.34	14.55	14.76
400	15.40	15.61	15.82	16.03	16.24	16.46	16.67	16.88	17.09	17.30	17.51	17.73	17.94	18.15	18.36	18.58	18.79	19.01
500	19.65	19.86	20.07	20.28	20.50	20.71	20.92	21.14	21.35	21.56	21.78	21.99	22.20	22.42	22.63	22.84	23.06	23.27
600	23.91	24.12	24.34	24.55	24.76	24.98	25.19	25.40	25.61	25.82	26.03	26.24	26.45	26.66	26.87	27.08	27.29	27.50
700	28.14	28.35	28.56	28.77	28.97	29.18	29.39	29.60	29.81	30.02	30.23	30.44	30.65	30.85	31.06	31.27	31.48	31.68
800	32.30	32.50	32.71	32.91	33.12	33.32	33.53	33.73	33.93	34.14	34.34	34.54	34.75	34.95	35.15	35.35	35.55	35.76
900	36.36	36.56	36.76	36.96	37.16	37.36	37.56	37.76	37.95	38.15	38.35	38.55	38.75	38.94	39.14	39.34	39.53	39.73
1000	40.31	40.51	40.70	40.90	41.09	41.29	41.48	41.67	41.87	42.06	42.25	42.44	42.63	42.83	43.02	43.21	43.40	43.59
1100	44.16	44.35	44.54	44.73	44.92	45.11	45.29	45.48	45.67	45.85	46.04	46.23	46.41	46.60	46.78	46.97	47.15	47.34
1200	47.89	48.07	48.25	48.43	48.62	48.80	48.98	49.16	49.34	49.52	49.69	49.87	50.05	50.23	50.41	50.58	50.76	50.94
1300	51.46	51.64	51.81	51.99	52.16	52.34	52.51	52.68	52.85	53.03	53.20	53.37	53.54	53.71	53.88			

PLATINUM-PLATINUM, 10% RHODIUM THERMOCOUPLES

Degrees Fahrenheit (Int. 1948) Cold End at 75° F (EMF at 32° F = -0.136 mv)

THERMOCOUPLE CALIBRATION DATA

EMF IN ABSOLUTE MILLIVOLTS																			
°F.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
°F.	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185
°F.	190	195	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275	280
°F.	285	290	295	300	305	310	315	320	325	330	335	340	345	350	355	360	365	370	375
°F.	380	385	390	395	400	405	410	415	420	425	430	435	440	445	450	455	460	465	470
°F.	475	480	485	490	495	500	505	510	515	520	525	530	535	540	545	550	555	560	565
°F.	570	575	580	585	590	595	600	605	610	615	620	625	630	635	640	645	650	655	660
°F.	665	670	675	680	685	690	695	700	705	710	715	720	725	730	735	740	745	750	755
°F.	760	765	770	775	780	785	790	795	800	805	810	815	820	825	830	835	840	845	850
°F.	855	860	865	870	875	880	885	890	895	900	905	910	915	920	925	930	935	940	945
°F.	950	955	960	965	970	975	980	985	990	995	1000	1005	1010	1015	1020	1025	1030	1035	1040
°F.	1045	1050	1055	1060	1065	1070	1075	1080	1085	1090	1095	1100	1105	1110	1115	1120	1125	1130	1135
°F.	1140	1145	1150	1155	1160	1165	1170	1175	1180	1185	1190	1195	1200	1205	1210	1215	1220	1225	1230
°F.	1235	1240	1245	1250	1255	1260	1265	1270	1275	1280	1285	1290	1295	1300	1305	1310	1315	1320	1325
°F.	1330	1335	1340	1345	1350	1355	1360	1365	1370	1375	1380	1385	1390	1395	1400	1405	1410	1415	1420
°F.	1425	1430	1435	1440	1445	1450	1455	1460	1465	1470	1475	1480	1485	1490	1495	1500	1505	1510	1515
°F.	1520	1525	1530	1535	1540	1545	1550	1555	1560	1565	1570	1575	1580	1585	1590	1595	1600	1605	1610
°F.	1615	1620	1625	1630	1635	1640	1645	1650	1655	1660	1665	1670	1675	1680	1685	1690	1695	1700	1705
°F.	1710	1715	1720	1725	1730	1735	1740	1745	1750	1755	1760	1765	1770	1775	1780	1785	1790	1795	1800
°F.	1805	1810	1815	1820	1825	1830	1835	1840	1845	1850	1855	1860	1865	1870	1875	1880	1885	1890	1895
°F.	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980	1985	1990
°F.	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085
°F.	2090	2095	2100	2105	2110	2115	2120	2125	2130	2135	2140	2145	2150	2155	2160	2165	2170	2175	2180
°F.	2185	2190	2195	2200	2205	2210	2215	2220	2225	2230	2235	2240	2245	2250	2255	2260	2265	2270	2275
°F.	2280	2285	2290	2295	2300	2305	2310	2315	2320	2325	2330	2335	2340	2345	2350	2355	2360	2365	2370
°F.	2375	2380	2385	2390	2395	2400	2405	2410	2415	2420	2425	2430	2435	2440	2445	2450	2455	2460	2465
°F.	2470	2475	2480	2485	2490	2495	2500	2505	2510	2515	2520	2525	2530	2535	2540	2545	2550	2555	2560
°F.	2565	2570	2575	2580	2585	2590	2595	2600	2605	2610	2615	2620	2625	2630	2635	2640	2645	2650	2655
°F.	2660	2665	2670	2675	2680	2685	2690	2695	2700	2705	2710	2715	2720	2725	2730	2735	2740	2745	2750
°F.	2755	2760	2765	2770	2775	2780	2785	2790	2795	2800	2805	2810	2815	2820	2825	2830	2835	2840	2845
°F.	2850	2855	2860	2865	2870	2875	2880	2885	2890	2895	2900	2905	2910	2915	2920	2925	2930	2935	2940
°F.	2945	2950	2955	2960	2965	2970	2975	2980	2985	2990	2995	3000	3005	3010	3015	3020	3025	3030	3035
°F.	3040	3045	3050	3055	3060	3065	3070	3075	3080	3085	3090	3095	3100	3105	3110	3115	3120	3125	3130
°F.	3135	3140	3145	3150	3155	3160	3165	3170	3175	3180	3185	3190	3195	3200	3205	3210	3215	3220	3225
°F.	3230	3235	3240	3245	3250	3255	3260	3265	3270	3275	3280	3285	3290	3295	3300	3305	3310	3315	3320

PLATINUM-PLATINUM, 10% RHODIUM THERMOCOUPLES

Degrees Celsius (Centigrade, Int. 1948) Cold End at 25°C (EMF at 0°C = -0.143 mv)

THERMOCOUPLE CALIBRATION DATA

EMF IN ABSOLUTE MILLIVOLTS																					
°C.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°C.
0	-0.143	-0.115	-0.087	-0.059	-0.030	0.000	0.030	0.061	0.092	0.123	0.156	0.188	0.221	0.254	0.288	0.323	0.357	0.392	0.428	0.464	0
100	0.500	0.537	0.574	0.611	0.649	0.687	0.726	0.764	0.803	0.843	0.882	0.922	0.963	1.003	1.044	1.085	1.126	1.168	1.209	1.251	100
200	1.293	1.336	1.378	1.421	1.464	1.507	1.550	1.593	1.637	1.681	1.725	1.769	1.813	1.857	1.902	1.947	1.992	2.037	2.082	2.127	200
300	2.173	2.219	2.264	2.310	2.356	2.403	2.449	2.495	2.542	2.588	2.635	2.682	2.729	2.776	2.823	2.871	2.918	2.965	3.013	3.060	300
400	3.108	3.156	3.204	3.251	3.299	3.347	3.396	3.444	3.492	3.540	3.589	3.637	3.686	3.735	3.783	3.832	3.881	3.930	3.979	4.028	400
500	4.078	4.127	4.176	4.226	4.276	4.325	4.375	4.425	4.475	4.525	4.575	4.625	4.675	4.726	4.776	4.827	4.877	4.928	4.979	5.030	500
600	5.081	5.132	5.183	5.234	5.286	5.337	5.389	5.440	5.492	5.543	5.595	5.647	5.699	5.751	5.803	5.855	5.907	5.959	6.012	6.064	600
700	6.117	6.169	6.222	6.275	6.328	6.381	6.434	6.487	6.540	6.594	6.647	6.701	6.754	6.808	6.862	6.915	6.969	7.023	7.077	7.132	700
800	7.186	7.240	7.295	7.349	7.404	7.459	7.513	7.568	7.623	7.678	7.733	7.789	7.844	7.899	7.955	8.010	8.066	8.122	8.177	8.233	800
900	8.289	8.345	8.402	8.458	8.514	8.571	8.627	8.684	8.740	8.797	8.854	8.911	8.968	9.025	9.082	9.139	9.197	9.254	9.312	9.369	900
1000	9.427	9.485	9.543	9.601	9.659	9.717	9.775	9.833	9.892	9.950	10.009	10.067	10.126	10.185	10.244	10.303	10.362	10.421	10.480	10.539	1000
1100	10.598	10.658	10.717	10.776	10.836	10.895	10.955	11.014	11.074	11.134	11.193	11.253	11.313	11.373	11.432	11.492	11.552	11.612	11.672	11.732	1100
1200	11.792	11.852	11.912	11.972	12.032	12.093	12.153	12.213	12.273	12.333	12.393	12.454	12.514	12.574	12.634	12.694	12.754	12.814	12.875	12.935	1200
1300	12.995	13.055	13.115	13.175	13.235	13.295	13.355	13.415	13.475	13.535	13.595	13.655	13.715	13.775	13.835	13.895	13.955	14.014	14.074	14.134	1300
1400	14.194	14.254	14.314	14.373	14.433	14.493	14.553	14.612	14.672	14.732	14.792	14.851	14.911	14.970	15.030	15.090	15.149	15.209	15.268	15.328	1400
1500	15.387	15.447	15.506	15.566	15.625	15.684	15.744	15.803	15.863	15.922	15.981	16.040	16.100	16.159	16.218	16.277	16.336	16.395	16.454	16.514	1500
1600	16.573	16.632	16.691	16.750	16.809	16.867	16.926	16.985	17.044	17.103	17.162	17.220	17.279	17.338	17.396	17.455	17.514	17.572	17.631	17.689	1600
1700	17.748	17.806	17.865	17.923	17.981	18.040	18.098	18.156	18.215	18.273	18.331	18.389	18.447	18.505							1700



°F

PLATINUM-PLATINUM, 13% RHODIUM THERMOCOUPLES

Degrees Fahrenheit (Int. 1948) Cold End at 75° F (EMF at 32° F = -0.135 mv)



THERMOCOUPLE CALIBRATION DATA

EMF IN ABSOLUTE MILLIVOLTS																								
° F.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	° F.			
0	-0.235	-0.220	-0.204	-0.188	-0.173	-0.157	-0.141	-0.126	-0.111	-0.096	-0.080	-0.064	-0.049	-0.032	-0.016	0.000	0.017	0.034	0.051	0.068	0			
100	0.085	0.102	0.120	0.137	0.156	0.173	0.192	0.210	0.228	0.246	0.265	0.284	0.303	0.322	0.341	0.361	0.381	0.401	0.421	0.441	100			
200	0.461	0.481	0.502	0.522	0.543	0.565	0.586	0.607	0.628	0.650	0.672	0.693	0.715	0.737	0.759	0.782	0.804	0.827	0.849	0.872	200			
300	0.895	0.917	0.940	0.963	0.986	1.009	1.032	1.056	1.079	1.103	1.126	1.150	1.174	1.198	1.222	1.246	1.271	1.295	1.320	1.345	300			
400	1.369	1.394	1.418	1.443	1.468	1.493	1.518	1.543	1.568	1.594	1.619	1.644	1.670	1.696	1.721	1.747	1.773	1.799	1.825	1.851	400			
500	1.877	1.903	1.930	1.956	1.982	2.009	2.035	2.062	2.088	2.115	2.142	2.168	2.195	2.222	2.249	2.277	2.303	2.331	2.358	2.385	500			
600	2.412	2.440	2.467	2.495	2.522	2.550	2.577	2.605	2.633	2.661	2.688	2.716	2.744	2.772	2.800	2.828	2.856	2.884	2.912	2.940	600			
700	2.968	2.997	3.025	3.053	3.082	3.110	3.138	3.167	3.195	3.224	3.252	3.281	3.310	3.338	3.367	3.396	3.425	3.453	3.483	3.512	700			
800	3.542	3.571	3.600	3.629	3.659	3.688	3.717	3.747	3.776	3.806	3.835	3.864	3.894	3.923	3.952	3.981	4.011	4.040	4.070	4.100	800			
900	4.129	4.159	4.189	4.219	4.249	4.278	4.308	4.338	4.368	4.398	4.428	4.458	4.489	4.519	4.550	4.580	4.611	4.641	4.672	4.702	900			
1000	4.733	4.764	4.795	4.825	4.856	4.887	4.918	4.949	4.980	5.011	5.041	5.073	5.103	5.135	5.166	5.197	5.228	5.259	5.291	5.322	1000			
1100	5.353	5.384	5.416	5.447	5.479	5.510	5.542	5.574	5.606	5.638	5.670	5.702	5.734	5.766	5.798	5.829	5.861	5.893	5.925	5.957	1100			
1200	5.990	6.021	6.053	6.085	6.117	6.150	6.182	6.214	6.246	6.279	6.311	6.344	6.376	6.409	6.442	6.474	6.507	6.539	6.572	6.605	1200			
1300	6.638	6.670	6.703	6.736	6.769	6.802	6.835	6.868	6.902	6.934	6.968	7.001	7.034	7.067	7.100	7.134	7.167	7.201	7.234	7.268	1300			
1400	7.301	7.335	7.368	7.402	7.436	7.470	7.504	7.537	7.571	7.605	7.639	7.673	7.707	7.742	7.776	7.810	7.844	7.878	7.912	7.946	1400			
1500	7.981	8.015	8.049	8.083	8.118	8.152	8.187	8.221	8.256	8.291	8.325	8.360	8.395	8.430	8.464	8.499	8.534	8.569	8.604	8.639	1500			
1600	8.674	8.709	8.744	8.779	8.814	8.849	8.884	8.919	8.955	8.990	9.026	9.061	9.097	9.132	9.168	9.203	9.239	9.274	9.310	9.346	1600			
1700	9.381	9.417	9.452	9.488	9.524	9.559	9.595	9.631	9.667	9.703	9.739	9.775	9.811	9.847	9.884	9.921	9.957	9.994	10.029	10.066	1700			
1800	10.102	10.139	10.175	10.212	10.248	10.285	10.321	10.358	10.394	10.431	10.468	10.504	10.541	10.577	10.614	10.651	10.688	10.726	10.763	10.801	1800			
1900	10.838	10.876	10.913	10.950	10.987	11.025	11.062	11.100	11.138	11.175	11.213	11.250	11.289	11.326	11.364	11.402	11.440	11.478	11.516	11.554	1900			
2000	11.591	11.630	11.667	11.705	11.743	11.781	11.819	11.857	11.894	11.933	11.970	12.009	12.047	12.085	12.123	12.161	12.200	12.238	12.276	12.315	2000			
2100	12.353	12.391	12.429	12.467	12.506	12.544	12.583	12.621	12.660	12.698	12.736	12.774	12.813	12.851	12.890	12.928	12.967	13.005	13.043	13.081	2100			
2200	13.120	13.158	13.197	13.236	13.274	13.313	13.351	13.390	13.429	13.467	13.506	13.544	13.583	13.621	13.660	13.698	13.737	13.776	13.814	13.853	2200			
2300	13.892	13.930	13.969	14.007	14.046	14.084	14.123	14.161	14.200	14.239	14.277	14.316	14.355	14.393	14.432	14.471	14.509	14.548	14.586	14.625	2300			
2400	14.663	14.702	14.740	14.779	14.817	14.856	14.894	14.933	14.972	15.010	15.049	15.087	15.126	15.164	15.203	15.242	15.280	15.319	15.357	15.396	2400			
2500	15.433	15.472	15.510	15.549	15.587	15.626	15.665	15.703	15.742	15.780	15.819	15.857	15.896	15.935	15.973	16.012	16.050	16.089	16.128	16.166	2500			
2600	16.205	16.243	16.282	16.320	16.359	16.397	16.436	16.475	16.513	16.552	16.590	16.629	16.667	16.707	16.745	16.783	16.822	16.860	16.898	16.937	2600			
2700	16.975	17.013	17.051	17.090	17.128	17.166	17.205	17.243	17.281	17.320	17.358	17.397	17.434	17.473	17.511	17.550	17.588	17.626	17.664	17.702	2700			
2800	17.740	17.778	17.816	17.854	17.892	17.930	17.968	18.006	18.044	18.083	18.120	18.159	18.197	18.235	18.273	18.311	18.349	18.387	18.425	18.463	2800			
2900	18.501	18.539	18.577	18.615	18.653	18.691	18.729	18.767	18.805	18.843	18.881	18.919	18.957	18.994	19.033	19.070	19.108	19.146	19.183	19.221	2900			
3000	19.259	19.297	19.335	19.373	19.410	19.448	19.486	19.524	19.562	19.600	19.638	19.676	19.713	19.751	19.789	19.827	19.864	19.902	19.940	19.977	3000			
3100	20.015																				3100			

EMF IN ABSOLUTE MILLIVOLTS

°C.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°C.
0	-0.142	-0.115	-0.087	-0.059	-0.030	0.000	0.030	0.061	0.092	0.123	0.156	0.188	0.221	0.255	0.289	0.323	0.358	0.394	0.430	0.467	0
100	0.503	0.541	0.579	0.617	0.656	0.695	0.735	0.775	0.815	0.856	0.897	0.938	0.979	1.021	1.063	1.105	1.148	1.191	1.235	1.278	100
200	1.323	1.367	1.411	1.456	1.501	1.546	1.592	1.637	1.684	1.730	1.776	1.823	1.870	1.917	1.965	2.012	2.060	2.108	2.156	2.204	200
300	2.253	2.302	2.351	2.400	2.449	2.499	2.548	2.598	2.648	2.698	2.748	2.798	2.849	2.899	2.950	3.001	3.052	3.103	3.154	3.205	300
400	3.257	3.309	3.360	3.412	3.465	3.517	3.570	3.622	3.675	3.728	3.781	3.834	3.887	3.939	3.992	4.045	4.099	4.152	4.206	4.259	400
500	4.313	4.367	4.421	4.476	4.530	4.585	4.640	4.695	4.751	4.806	4.862	4.917	4.973	5.028	5.084	5.140	5.196	5.252	5.308	5.365	500
600	5.421	5.478	5.535	5.592	5.650	5.707	5.765	5.822	5.880	5.937	5.995	6.052	6.110	6.168	6.226	6.285	6.343	6.402	6.460	6.519	600
700	6.578	6.637	6.696	6.756	6.815	6.875	6.934	6.994	7.053	7.113	7.173	7.234	7.294	7.355	7.415	7.476	7.537	7.598	7.659	7.721	700
800	7.782	7.844	7.905	7.967	8.028	8.090	8.152	8.214	8.277	8.339	8.402	8.464	8.527	8.590	8.653	8.716	8.779	8.842	8.905	8.969	800
900	9.033	9.097	9.161	9.225	9.289	9.353	9.417	9.481	9.545	9.610	9.674	9.739	9.804	9.870	9.935	10.001	10.066	10.132	10.197	10.263	900
1000	10.329	10.395	10.461	10.527	10.593	10.659	10.727	10.794	10.861	10.928	10.996	11.063	11.131	11.198	11.266	11.334	11.402	11.471	11.539	11.607	1000
1100	11.675	11.743	11.812	11.880	11.948	12.017	12.085	12.154	12.223	12.292	12.361	12.430	12.499	12.568	12.637	12.706	12.775	12.844	12.913	12.983	1100
1200	13.051	13.121	13.190	13.260	13.329	13.398	13.468	13.537	13.607	13.676	13.746	13.815	13.885	13.954	14.023	14.093	14.162	14.232	14.301	14.371	1200
1300	14.440	14.510	14.579	14.649	14.718	14.787	14.857	14.926	14.996	15.065	15.134	15.203	15.273	15.342	15.411	15.481	15.550	15.619	15.689	15.758	1300
1400	15.827	15.897	15.966	16.036	16.105	16.175	16.244	16.313	16.382	16.452	16.521	16.591	16.660	16.730	16.798	16.868	16.937	17.006	17.075	17.144	1400
1500	17.213	17.282	17.351	17.419	17.489	17.557	17.626	17.695	17.764	17.832	17.901	17.969	18.037	18.106	18.174	18.243	18.311	18.380	18.448	18.517	1500
1600	18.585	18.654	18.722	18.790	18.859	18.927	18.995	19.063	19.131	19.199	19.267	19.335	19.403	19.472	19.540	19.608	19.676	19.744	19.812	19.880	1600
1700	19.948																				1700

BRISTOL'S[®] MODEL 565 ROUND-CHART DYNAMASTER

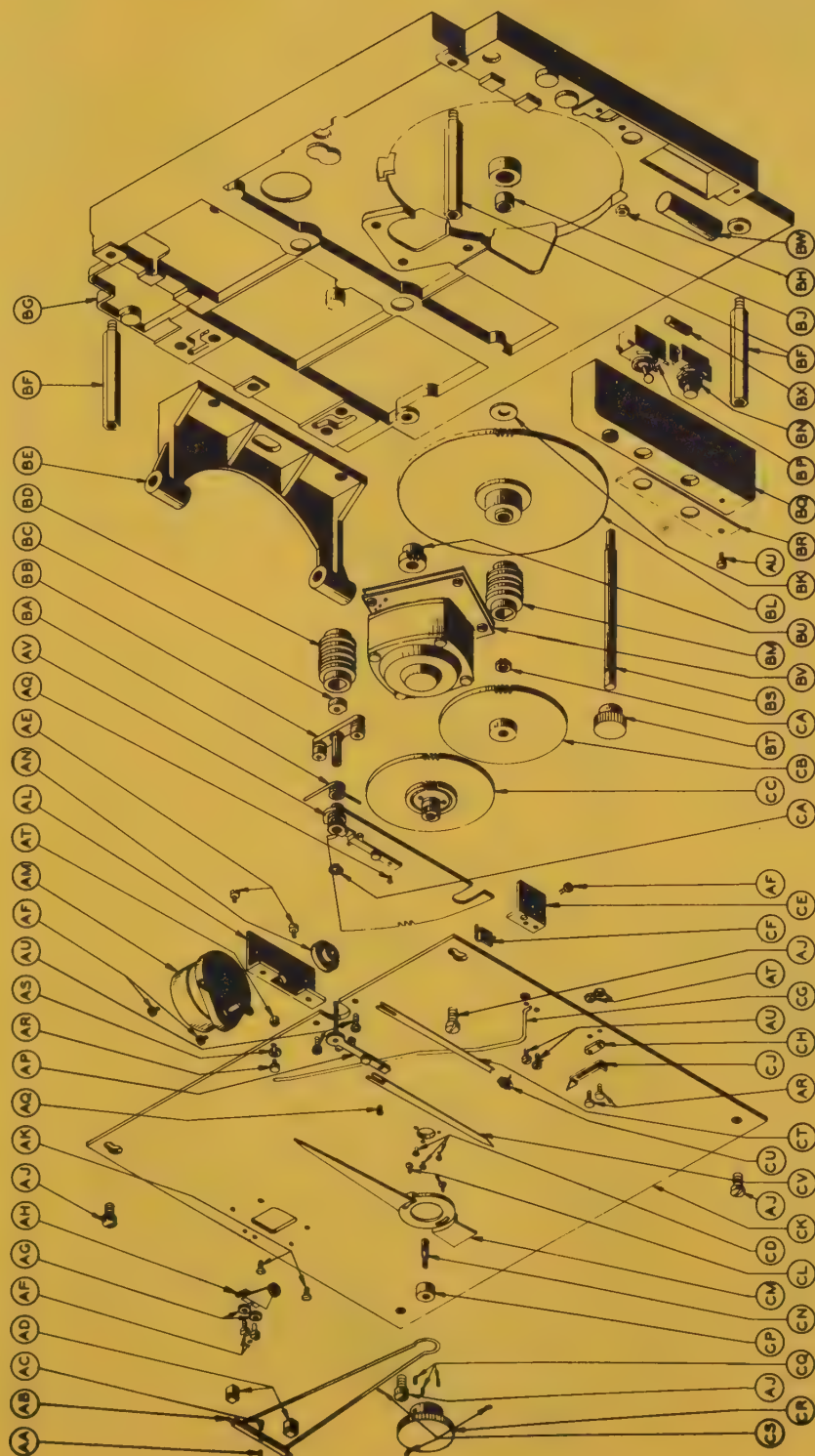


FIGURE 1. EXPLODED VIEW OF DYNAMASTER SWINGING PANEL (FRONT VIEW)

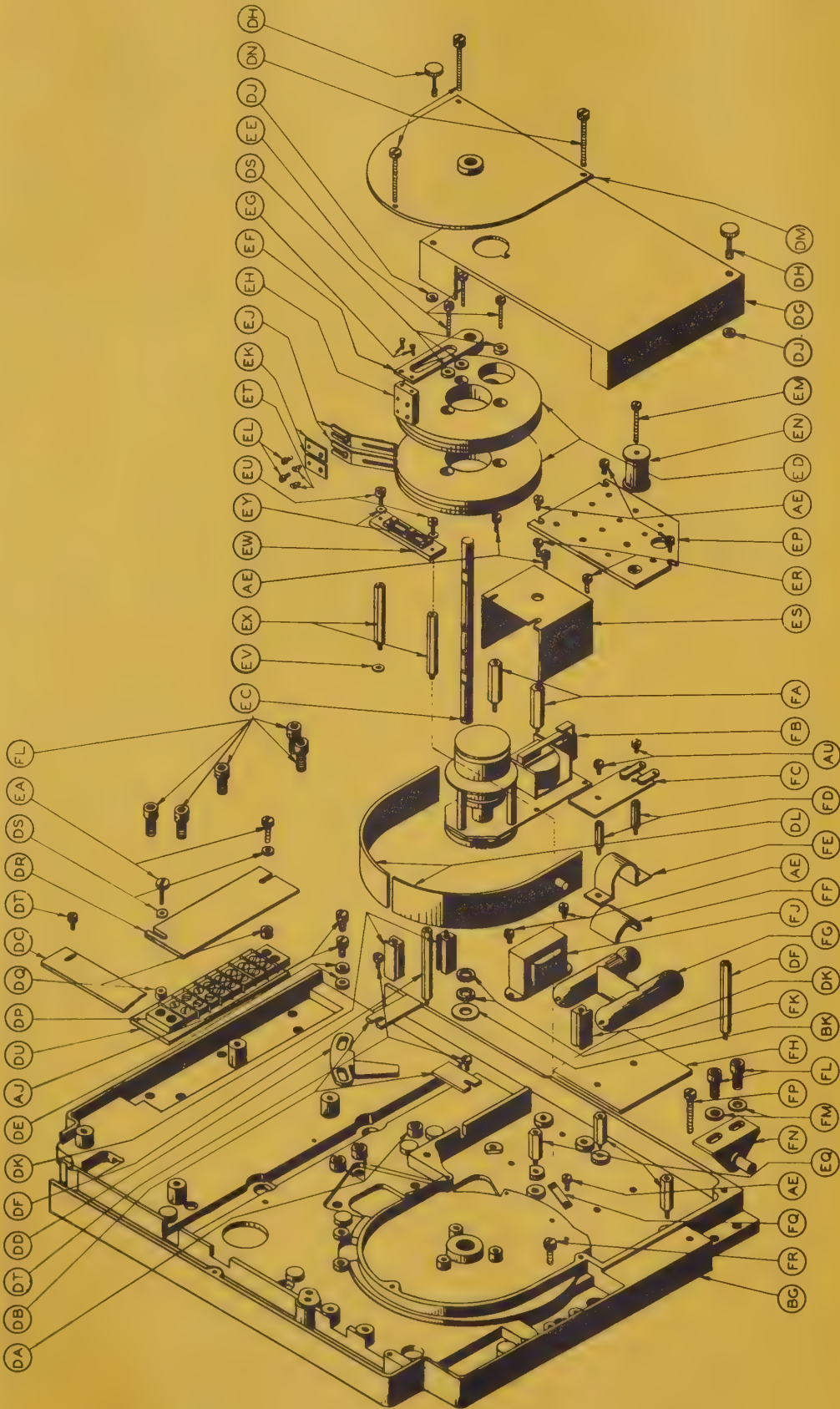


FIGURE 2. EXPLODED VIEW OF DYNAMASTER SWINGING PANEL (REAR VIEW)

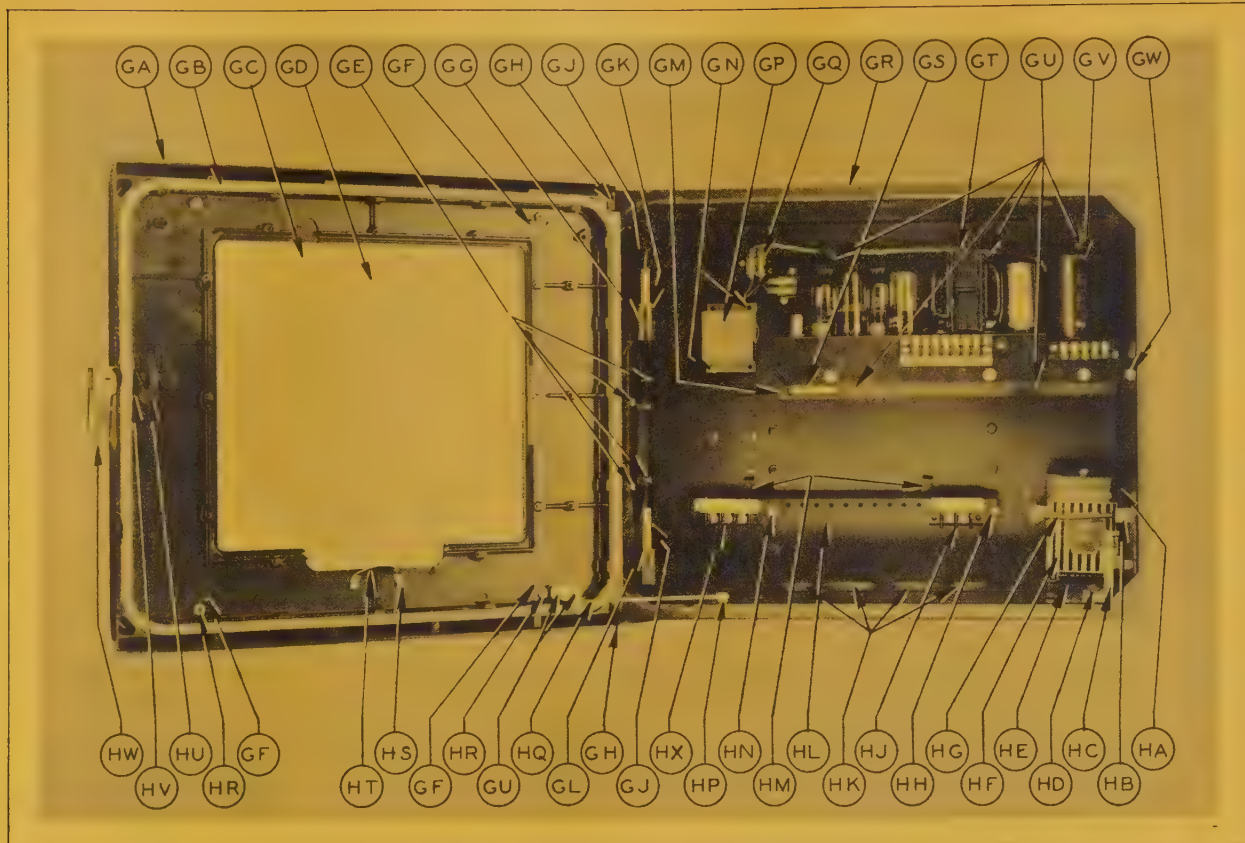


FIGURE 3. INTERIOR VIEW OF DYNAMASTER CASE

BE SURE TO STATE MODEL AND SERIAL NUMBERS OF INSTRUMENT WHEN ORDERING PARTS

ITEM	DESCRIPTION	PART NO.
AA	5-40 x 1/8" Bristo flat-point setscrew	
AB	Pointer support	93028
AC	5-40 x 7/64" Special adjusting screw	93057
AD	Pivot block	93019
AE	6-40 x 5/16" Fillister-head screw	31427
AF	6-40 x 3/16" Fillister-head screw	18339
AG	Washer	21252
AH	Friction-roller assembly	94407
AJ	10-32 x 3/8" Fillister-head screw	66539
	10-32 x 3/8" Special-head screw for upper right-hand corner	94425
AK	6-40 x 3/16" Flat-head screw	69848
AL	Chart-drive-motor mounting bracket: For 8-hour, 12-hour, 24-hour or 72-hour chart rotation	93020
	For 7-day chart rotation	93096
AM	Chart-drive motor: 120-volt, 60-cycle, 1/40-rpm motor for 8-hour chart rotation	93097
	120-volt, 60-cycle, 1/60-rpm motor for 12-hour chart rotation	92362
	120-volt, 50-cycle, 1/60-rpm motor for 12-hour chart rotation	93934
	120-volt, 25-cycle, 1/60-rpm motor for 12-hour chart rotation	93939
	120-volt, 60-cycle, 1/2-rph motor for 24-hour chart rotation	93022
	120-volt, 50-cycle, 1/2-rph motor for 24-hour chart rotation	93935
	120-volt, 25-cycle, 1/2-rph motor for 24-hour chart rotation	93940
	120-volt, 60-cycle, 1/6-rph motor for 72-hour chart rotation	92363
	120-volt, 60-cycle, 1/15-rph motor for 7-day chart rotation	92364
	120-volt, 50-cycle, 1/15-rph motor for 7-day chart rotation	93937
	120-volt, 25-cycle, 1/15-rph motor for 7-day chart rotation	93942
AN	Friction-drive wheel not including setscrew: For 8-hour, 12-hour, 24-hour or 72-hour chart rotation	93017
	For 7-day chart rotation	93095
Not Shown	6-40 x 1/8" Bristo flat-point setscrew for friction-drive wheel	82403
AP	Set-point-index base end including item AQ	93079
AQ	1-72 x 3/32" Special-head screw	82591
AR	6-40 x 9/32" Round-head slotless screw	23945
AS	Pen-lifter stop	93012
AT	6-40 Hex nut	20903
AU	6-40 x 1/4" Special-head screw	91039

BE SURE TO STATE MODEL AND SERIAL NUMBERS OF INSTRUMENT WHEN ORDERING PARTS

ITEM	DESCRIPTION	PART NO.
AV	Segment-gear assembly including Item AQ	93000
BA	Spring	91899
BB	Segment-gear support bracket	91896
BC	Coupling adapter not including setscrew	93073
Not Shown	6-40 x 1/8" Bristo flat-point setscrew for coupling adapter	82403
BD	Flexible coupling including setscrews	91891
	10-32 x 3/16" Slotted flat-point setscrew	93033
	10-32 x 1/4" Bristo flat-point setscrew	82414
BE	Bracket	83996
BF	Post	93035
BG	Mounting frame	85251
BH	10-32 Hex nut	72055
BJ	Needle bearing	86043
BK	Thrust washer	24804
BL	Bull gear not including setscrew	86052
Not Shown	5/16"-18 x 5/16" Bristo flat-point setscrew	89049
BM	Flexible coupling including setscrews	93038
	10-32 x 3/16" Slotted flat-point setscrew	93033
	10-32 x 3/16" Bristo flat-point setscrew	82413
BN	Push-button switch	54261
BP	Toggle switch	62182
BQ	Switch housing	86025
BR	Switch plate for a-c instrument (1 switch)	86099
	Switch plate for d-c instrument (2 switches)	86098
BS	Set-point-index-knob shaft	88175
BT	Set-point-index-knob not including setscrew	89132
Not Shown	10-32 x 3/16" Bristo flat-point setscrew	82413
BU	Motor pinion including setscrew:	
	For instrument with 24 second pen travel	91930
	For instrument with 4.5 second pen travel	86036
	For instrument with 3 or 1 second pen travel	91932
	For instrument with 2/3 second pen travel	93314
	6-40 x 1/4" Bristo flat-point setscrew	85855
BV	Balancing motor:	
	24 second pen speed, motor and gear train complete	96874
	Motor with pinion (120 volt 60 cycles)	96872
	Gear complete (88 teeth - 64 pitch x 15 teeth - 48 pitch)	97652
	Gear complete (120 teeth - 48 pitch)	97647
	4.5 second pen speed, motor and gear train complete	96849
	Motor, with pinion (120 volt - 60 cycles)	96600
	Gear complete (140 teeth - 64 pitch)	96859
	3 second pen speed motor and gear train complete	96848
	Motor with pinion (120 volt - 60 cycles)	96600
	Gear complete (88 teeth - 64 pitch)	96868
	1 second pen speed, motor and gear train complete	96873
	Motor (120 volt - 60 cycles)	96871
	Pinion (26 teeth - 64 pitch) order with 6-40 x 1/8" flat-point setscrew #82403 ..	97640
	Gear complete (72 teeth - 64 pitch)	97638
	2/3 second pen speed, motor (120 volt - 60 cycle)	91038
BW	Capacitor (.1 mfd - 600 WVDC)	83990
BX	Resistor (47 ohm)	91045
CA	Retaining ring	79854
CB	Gear	93005
CC	Center arbor complete	93039
CD	4-48 x .165" Special flat-head screw	93025
CE	Pen-lifter bracket	93011
CF	Pen-lifter clamp	84103
CG	Pen lifter	93010
CH	Spring	93009
CJ	Time indicator	93008
CK	Chart plate complete	91892
	Knob and indicator assembly complete including Items CL to CS	93047
CL	2-64 x 1/8" Fillister-head screw	92992
CM	Pointer	93048
CN	Magnet guide screw	93051
CP	Magnet	93050
CQ	5-40 x 3/16" Flat-point setscrew	
CR	Knob	93049
CS	Guide screw	93052
CT	Pen arm	93024
CU	Pen	93054
CV	Set-point index	93068
DA	Motor-mounting nut	86053
DB	Cable cover	85273
DC	Cable cover	91678

BE SURE TO STATE MODEL AND SERIAL NUMBERS OF INSTRUMENT WHEN ORDERING PARTS

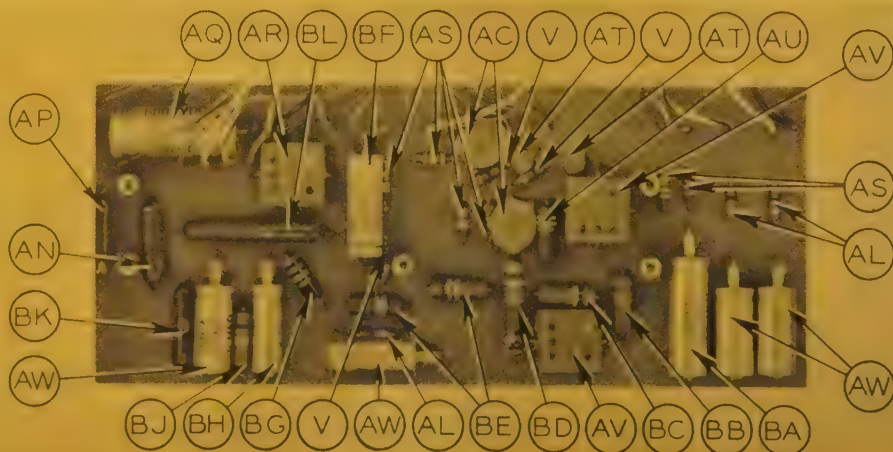
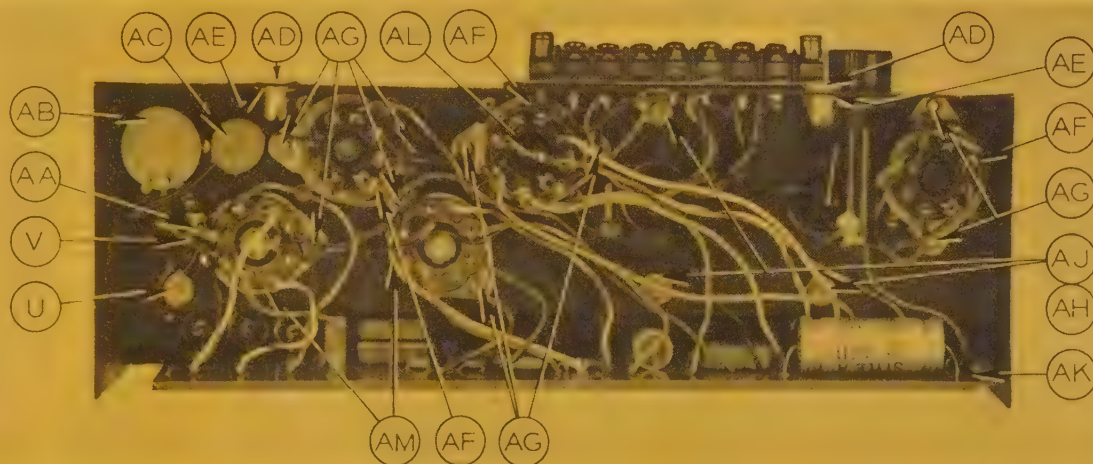
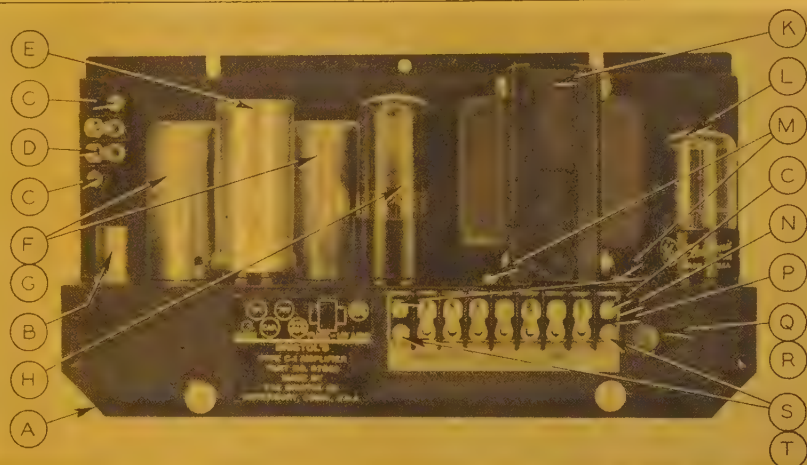
ITEM	DESCRIPTION	PART NO.
DD	Gear stop	85272
DE	Washer	10075
DF	Post	86014
DG	Cover for resistance spools for a-c Dynamaster	89113
	Cover for resistance spools for d-c Dynamaster	86015
DH	Thumb screw	55785
DJ	Washer	82381
DK	Post	89112
DL	Slide-wire cover	89865
DM	Slide-wire back plate for recorder	89104
	Slide-wire back plate for micro-act controller	88164
DN	10-32 x 1½" Fillister-head screw	65984
DP	Terminal block (8 point)	95611
DQ	Spacer	45081
DR	Terminal-block cover	95614
DS	#6 Lockwasher	43040
DT	6-40 x 1/4" Fillister-head screw	39770
DU	Terminal block marking strip (8 point)	95612
EA	6-40 x 3/4" Fillister-head screw	41519
EC	Main shaft	93034
ED	Slide wire, order by Model and Serial number of instrument	
EE	6-40 x 5/8" Fillister-head screw for one slide wire	19536
	6-40 x 7/8" Fillister-head screw for two slide wires	36344
	Sliding-contact arm complete including items EF to EL and ET:	
	For one slide wire	95639
	For two slide wires	95638
EF	Contact arm including setscrew	89100
	10-32 x 3/16" Bristo flat-point setscrew	82413
EG	3-56 x 1/4" Flat-head screw	11394
EH	Mounting plate	95624
EJ	Sliding contact	89114
EK	Clamping strip	95637
EL	3-56 x 3/16" Fillister-head screw	18371
EM	6-32 x 1 1/8" Self-tapping screw	91046
EN	Calibration spool (order by model and serial numbers of instrument, giving information on spool label)	
EP	Mounting plate	86051
EQ	Post	88141
ER	6-40 x 9/16" Fillister-head screw	34976
ES	Relay cover	85284
ET	3-56 Shoulder screw	25647
EU	4-48 x 5/16" Fillister-head screw	51556
EV	Washer	74041
EW	Trimmer	95412
EX	Post	95424
EY	Washer	95425
FA	Post	93026
FB	Standardizing mechanism	88119
FC	Terminal plate	87502
FD	Post	77020
FE	Clamp	62645
FF	Clamping felt	62646
FG	Standard cell	62327
FH	Mounting plate	85791
FJ	Transformer for 50 or 60 cycle	84245
	Transformer for 25 cycle	72557
FK	Retaining ring	89117
FL	1/4"-20 x 1/2" Hex-cap screw	89660
FM	Washer	38811
FN	Latch pin complete	85296
FP	10-32 x 1 1/8" Fillister-head screw	47042
FQ	Clamp	89118
FR	10-32 x 1/2" Fillister-head screw	66541
GA	Door complete including door and items GB, HU, HV and HW	92198
	Door (order drilled per sheets 92199 & 85023)	83057
GB	Gasket (62")	82608
GC	Scale (order by model and serial numbers of instrument)	
GD	Glass	91889
GE	10-32 x 1/2" Fillister-head screw	66541
	10-32 x 3/8" Fillister-head screw	66539
GF	6-40 x 1/4" Fillister-head screw	39770
Not Shown	Washer	6965
GG	Bracket not including setscrews	85236
Not Shown	10-32 x 3/16" Bristo flat-point setscrew	82413
GH	Hinge	82654

BE SURE TO STATE MODEL AND SERIAL NUMBERS OF INSTRUMENT WHEN ORDERING PARTS

ITEM	DESCRIPTION	PART NO.
Not Shown	10-32 x 3/8" Special-head screw	92693
Not Shown	Washer	10075
GJ	Hinge pin	85208
GK	Washer	12721
GL	Washer	30401
GM	Shelf	89124
GN	6-40 x 5/16" Fillister-head screw	31427
Not Shown	Post	56498
Not Shown	Washer	556
GP	Input transformer for 50 or 60 cycles	91934
	Input transformer for 25 cycles	94202
GQ	Terminal block	89131
	6-40 x 7/16" Fillister-head screw	58073
GR	Case complete including case body and items GE, GG, GW, HC and HD	93999
	Case body	85201
GS	Capacitor for 50 or 60 cycles (1 mfd)	73557
	Capacitor for 25 cycles (2.5 mfd)	67491
Not Shown	6-32 x 3/16" Binding-head screw	82656
GT	Series C Amplifier - See parts list PI2075 for breakdown of parts:	
	For 50 - 60 cycle	90640
	For 25 cycle	93956
	Series C-1 Amplifier - See parts list PI2077 for breakdown of parts:	
	For 60 cycle	97600
GU	8-32 x 1/4" Fillister-head screw	40066
GV	Syncroverter switch	89189
GW	Roller stud	85212
	Roller	85213
HA	Insulation pad behind battery	86001
HB	Battery-spring bracket	85266
	6-40 x 3/16" Fillister-head screw	18339
HC	Latch complete	85220
HD	1/4"-20 x 3/8" Hex-cap screw	89659
HE	Insulation pad under battery	88142
HF	Battery (1.5 volt)	64933
	Battery (6 volt)	67489
HG	Battery spring	85297
	Battery-spring insulation	86000
HH	10-32 x 1 1/2" Fillister-head screw	65984
Not Shown	Spacer	88102
HJ	Terminal block (3-point)	87235
	Terminal block (2-point)	74804
	Marking strip for 3-point terminal block	76318
	Marking strip for 2-point terminal block	76319
	10-32 x 1" Self-tapping screw for mounting terminal block	87936
Not Shown	Washer for screw	10075
Not Shown	Spacer under marking strip	72166
HK	Large grommet	86026
	Small grommet	72691
HL	Terminal strap	86092
HM	Cable clamp	86032
	6-40 x 3/16" Fillister-head screw	18339
HN	10-32 x 1 1/2" Flat-head screw	66572
Not Shown	Spacer	88102
HP	Door-stop screw	87392
	Spacer	44739
HQ	Door stop	86027
HR	8-32 Hex nut	26966
HS	6-40 x 5/16" Flat-head screw	20335
	6-40 Hex nut	20903
HT	Chart retainer	93053
HU	Hook complete including setscrew	88751
HV	Spring	82630
HW	Handle	82615
HX	Terminal block (3-point)	87235
	Marking strip	86046
	10-32 x 1" Self-tapping screw for mounting terminal block	87936
Not Shown	Washer for screw	10075
Not Shown	Spacer under marking strip	72166

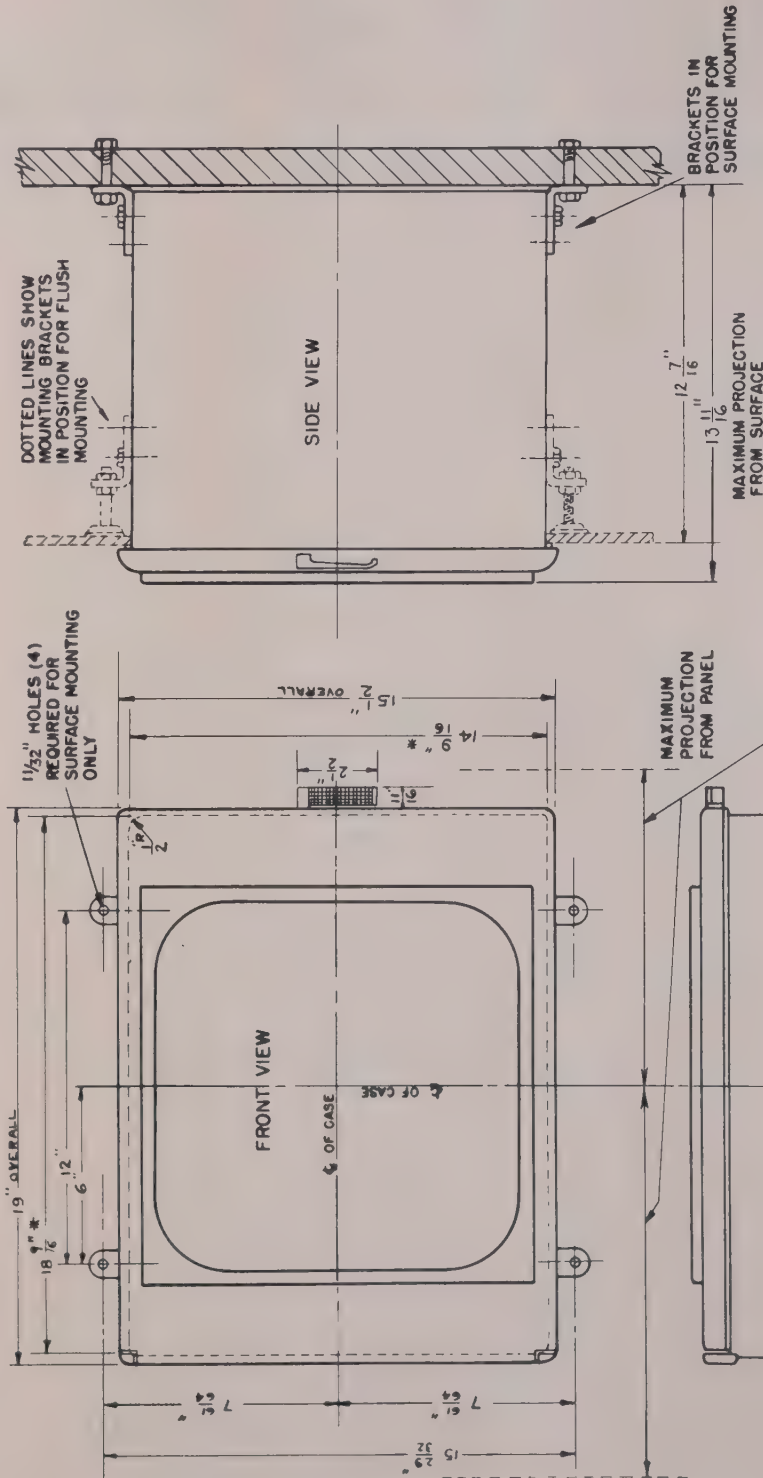
DESCRIPTION	PART NO.
<u>NOT SHOWN</u>	
Cover extension complete (includes also Item GD)	91887
Cover extension	91888
Glass clip	79902
4-48 x 3/32" Fillister-head screw for glass clip	33708
Gasket under glass (cork)	84725
Gasket between extension and cover (rubber)	91890
Name-plate assembly	
Name plate	88321
Name-plate cover	88209
6-32 x 1/4" Self-tapping screw	88824
Wire clamps mounted on bracket Item GG	
Wire clamp (4)	86033
10-32 x 3/16" Fillister-head screw (4)	66536
Wire clamp (1)	77139
8-32 x 1/4" Fillister-head screw (1)	40066
Preamplifiers	
Shock-mounted (2-stage)	
Preamplifier not including mounting parts	
For 4000-ohm input	93930
For 500-ohm input	94411
Rubber mounting post	86107
Mounting plate	93921
Shock absorber	85534
Post for shock absorber	93922
8-32 Hex nut	26966
6-40 x 3/16" Fillister-head screw	18339
Non-shock-mounted (single-stage)	
Preamplifier not including mounting screws	
For 4000-ohm input	92760
For 500-ohm input	92732
6-40 x 1" Fillister-head screw	49952
Automatic-standardization timer	
Timer complete not including mounting parts	
For 50- or 60-cycle	93308
For 25-cycle	93955
60-40 x 3/16" Fillister-head screw for mounting timer	18339
Case mounting brackets	
Bracket	92030
1/4"-20 x 1/2" Hex-head screw	32193
5/16"-24 x 2 1/2" Headless screw	83848
5/16"-24 Hex nut	50706
Cup washer	92031
Constant-voltage unit complete	91936
<u>EXTRA PARTS FOR 25-CYCLE DYNAMASTERS</u>	
Capacitor mounted on right under shelf	
Capacitor	74480
6-32 x 3/16" Binding-head screw	82656
Output transformer on back of case	
Output transformer	92736
8-32 x 7/16" Fillister-head mounting screw	64029
Spacer for mounting screw	72166
Rubber grommet for wiring connections	85177
Resistor mounted on back of swinging panel for d-c Dynamaster	
Resistor (150 ohm, 25W)	93961
Washer (1)	45078
Washer (2)	35218
6-40 x 2 1/4" Fillister-head screw	65876

**BRISTOL'S® SERIES C-1 & SERIES D AMPLIFIERS
USED IN SERIES 560, 565 & 570 DYNAMASTERS**



BE SURE TO STATE MODEL AND SERIAL NUMBERS OF INSTRUMENT WHEN ORDERING PARTS

ITEM NUMBER	PART NO.	DESCRIPTION
	97600	Series C-1 Amplifier complete
	C1096	Series D Amplifier complete
A	C1083	Chassis complete for series C-1 amplifier
	C1097	Chassis complete for series D amplifier
B	84549	Potentiometer shaft cap
C	86100	6-32 x 1/2" Self-tapping screw
D	83987	Terminal block (2-point)
E	83974	Capacitor
F	91040	Tube shield
G	90596	7F7 Tube
H	83972	6V6 GT Tube for series C-1 amplifier
	A2236	5881 Tube for series D amplifier
K	90582	Transformer for series C-1 amplifier
	B1215	Transformer for series D amplifier
NOT SHOWN	A2240	Transformer mounting plate for series D amplifier
	A2238	8-32 x 5/8" Flat-head screw for above plate
	A2239	Spacer for above plate
L	90595	6X5 GT Tube
M	40067	8-32 x 3/8" Fillister-head screw for series C-1 amplifier
	40066	8-32 x 1/4" Fillister-head screw for series D amplifier
N	91946	Marking strip (7-point)
P	90594	Terminal block (7-point)
NOT SHOWN	90636	Shield over 7-point terminal block
Q	84716	Fuse holder
R	64283	Fuse (1/8-amp little fuse)
S	90444	6-32 x 5/8" Self-tapping screw
T	45081	Collar
U	97630	Capacitor (ceramic) (470 microfarad $\pm$ 10% tolerance)
V	83980	Resistor (1 megohm, 1/2 watt, $\pm$ 10% tolerance)
AA	83981	Resistor (4.7 megohm, 1/2 watt $\pm$ 10% tolerance)
AB	97601	Potentiometer (C-taper) (1 megohm $\pm$ 20% tolerance)
AC	97631	Capacitor (ceramic) (.02 microfarad, 1000 volt, $\pm$ 20% tolerance)
AD	89121	Dzus fastener
AE	89122	Washer
AF	71708	Octal socket
AG	92359	Eyelet for mounting tube sockets
AH	26966	8-32 Hex nut
AJ	35639	Lockwasher
AK	97632	Printed-circuit assembly complete for series C-1 amplifier (includes items V, AC and AN thru BL)
	B1214	Printed-circuit assembly complete for series D amplifier (includes items V, AC, AN thru BF, and BH thru BL)
	97602	Printed-circuit board only
AL	72226	Resistor (10,000 OHM, 1/2 watt $\pm$ 10% tolerance)
AM	90593	Octal socket
AN	97619	Resistor (10,000 OHM, 5 watt $\pm$ 5% tolerance)
AP	97617	Resistor (250 OHM, 5 watt $\pm$ 5% tolerance)
AQ	97627	Capacitor (paper) (.25 microfarad, 600 volt, $\pm$ 20% tolerance)
AR	97628	Capacitor (mica) (.003 microfarad, 300 volt, $\pm$ 2% tolerance) for C-1 only
AS	83979	Resistor (470,000 OHM, 1/2 watt $\pm$ 10% tolerance)
AT	97629	Capacitor (ceramic) (250 micromicrofarad, 1,000 volt, $\pm$ 10% tolerance)
AU	97684	Resistor (240,000 OHM, 1/2 watt $\pm$ 1% tolerance)
AV	90592	Capacitor (mica) (.0062 microfarad, 300 volt, $\pm$ 5% tolerance)
AW	97625	Capacitor (electrolytic) (25 microfarad, 50 volt - 10% + 150% tolerance)
BA	97624	Capacitor (electrolytic) (12 microfarad, 250 volt - 10% + 150% tolerance)
BB	97683	Resistor (75,000 OHM, 1/2 watt $\pm$ 1% tolerance) for C-1 amplifier
	89085	Resistor (68,000 OHM, 1 watt $\pm$ 10% tolerance) for D amplifier
BC	97685	Resistor (300,000 OHM, 1/2 watt $\pm$ 1% tolerance)
BD		Calibrating resistor (as required when parallel "T" is tuned)
BE	87018	Resistor (100,000 OHM, 1 watt $\pm$ 10% tolerance)
BF	97626	Capacitor (paper) (.022 microfarad, 600 volts $\pm$ 10% tolerance)
BG	97622	Resistor (680,000 OHM, 1 watt $\pm$ 5% tolerance) for C-1 amplifier only
BH	97623	Capacitor (electrolytic) (1 microfarad, 50 volt - 10% + 150% tolerance) for series C-1
	97625	Capacitor (electrolytic) (25 microfarad, 50 volt - 10% + 150% tolerance) for series D
BJ	97621	Resistor (10,000 OHM, 1 watt, $\pm$ 5% tolerance)
BK	97618	Resistor (1,000 OHM, 5 watt, $\pm$ 5% tolerance) for series C-1
	97617	Resistor (250 OHM, 5 watt $\pm$ 5% tolerance) for series D
BL	97620	Resistor (22,000 OHM, 10 watt $\pm$ 5% tolerance)
	NOT SHOWN	
	77587	6-32 x 3/16" Binding-head screw for mounting printed circuit board to chassis
	A2237	Connector-receptacle for series D amplifier
	92359	Eyelet for mounting above receptacle



ALLOW A SPACE OF 11 1/2" FROM
SIDE OF OTHER APPARATUS TO
CL OF THIS INSTRUMENT FOR
DOOR CLEARANCE

* NOTE: PANEL CUTOUT DIMENSIONS
14 9/16" X 18 9/16"
MAXIMUM PANEL THICKNESS
1 7/8"

INSTRUCTION NO. A1430-B

(Issue No. 1 of 1/56)

INSTALLATION, OPERATION AND SERVICE DERIVATIVE, RESET AND RESET-PLUS-DERIVATIVE SERIES 500W AIR-OPERATED FREE-VANE® CONTROLLERS

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THE BRISTOL COMPANY

WATERBURY 20, CONN.

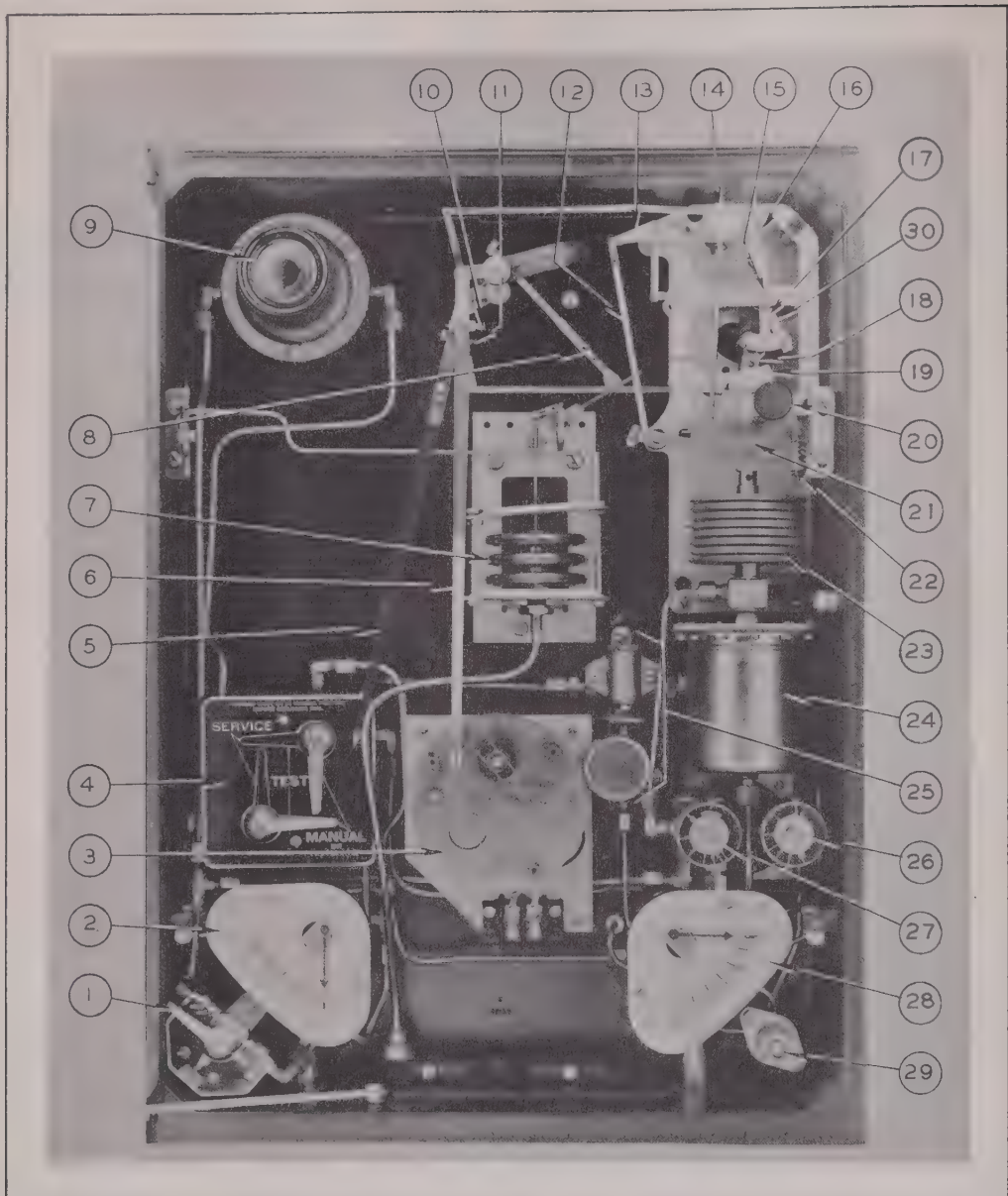


FIGURE 1. TYPICAL SERIES 500W WIDE-BAND RESET-PLUS-DERIVATIVE CONTROLLER

CODE TO FIGURE 1

- | | |
|--|------------------------------------|
| 1. Manual-automatic valve | 16. Differential lever |
| 2. Output air gauge | 17. Vane reversal lever |
| 3. Chart drive (electric) | 18. Nozzle assembly |
| 4. Test and service valves | 19. Proportional-band-width scale |
| 5. Set-point index | 20. Set-point-index adjusting knob |
| 6. Pen arm | 21. Rocker arm |
| 7. Measuring element | 22. Rocker-arm adjusting nut |
| 8. Measuring-element linkage | 23. Feedback bellows |
| 9. Pressure regulator | 24. Reset bellows |
| 10. Pen microadjustment | 25. Pilot valve |
| 11. Set-point-index microadjustment | 26. Derivative-time adjusting knob |
| 12. Reversing link | 27. Reset-rate adjusting lever |
| 13. Tee lever | 28. Supply air gauge |
| 14. Proportional-band-width adjusting knob | 29. Equalizing button |
| 15. Vane bearing screw and lock nut | 30. Vane positioning arm |

Note: This instruction covers only the controlling system. See separate instructions covering case mounting, measuring system, recording system, etc.

PART I GENERAL DESCRIPTION

Bristol's Reset and Reset-plus-Derivative Controllers Series 500CW and 500EW offer 1 to 200% and 2 to 400% proportional-band widths which are continuously adjustable throughout the ranges of 1 to 200% of the chart width or 2 to 400% of the chart width.

The Derivative Controller Series 500DW has a proportional band of 100% as standard.

The Controllers consist of three major units: the measuring system, the control unit and the pilot valve.

As the measuring element moves with changes in the controlled variable, the vane is moved in and out between the air jets. The jet back pressure varies as the leading edge of the vane passes between the jets. This change in back pressure extends and contracts the pilot-valve capsule. The capsule positions the pilot-valve ball so that it controls the output air pressure to the control valve.

These changes in output air pressure also cause changes in the length of the feedback bellows. This bellows motion, thru the feedback linkages, retracts a part of the vane motion originally caused by the measuring element. This causes a reduction in sensitivity of the vane and jet. The amount of feedback motion is adjustable by moving the fulcrum back and forth on the rocker arm. Thus, by means of adjustable negative feedback, the proportional band of the control unit can be

changed from 1 to 200% or 2 to 400% of full range.

Derivative and/or reset actions are obtained by manipulating the pressure in the feedback bellows by means of air capacities and adjustable restrictions to air flow.

A. Accessories

It is often desirable to be able to switch from automatic to manual control of a process for special conditions in the process itself or for service or removal of the air-operated controller. The Bristol Company can supply a variety of internal and external accessories especially designed for easy and efficient switching to manual control, testing or service positions.

1. Internal Accessories. Manual-automatic, manual-service and pressure regulating valves are mounted and connected inside the instrument when so ordered. Instructions for their use may be found on a decal on the inside of the instrument door and repeated on page 9 of this instruction.

2. External Accessories. Manual-automatic, manual-service and pressure regulating valves for external requirements are mounted on a panel which can be mounted directly adjacent to any Bristol Series 500, 560 or 565 Air-operated Controller or separately. Separate instructions will be supplied for their use.

PART II INSTALLATION

A. Standard Accessories

All Series 500W air controllers are supplied with one Quick-clean air filter. This will be found in a cloth bag tied to the instrument.

A red sticker on the outside of the shipping box lists the number of pieces or packages in the box. Be sure to find all pieces before discarding the packing.

B. Location of the Instrument

The controller may be mounted on a panel or wall. Universal mounting brackets are provided for either location. Choose a place as free as possible from dust, dirt, vibration, corrosive fumes and extremes of temperature. See separate instructions covering the details of installing the case.

C. Air Connections to Case

The air connections can be made either to the back or bottom of the case. If the desired connections have been specified on the sales order, the connections not used will be sealed with 1/4" pipe plugs, and plastic screw plugs will be in the other connections. Remove and discard these plastic plugs and make the necessary piping connections.

D. Quick-clean Air Filter

Bristol's Quick-clean air filter should be screwed directly into the air supply inlet on the controller. This filter serves as an elbow and should face in the required direction. It may be used with case connections in either the bottom or rear of the case.

E. Supply Air

It is strongly recommended that the air supply to the controller be clean, dry and oil free. Air compressors should be equipped with air filters and condensate traps and should be frequently serviced. Most difficulties in air control systems are caused by dirty, wet or oily air supplies.

The supply air pressure must be 20 pounds per square inch (psi). This pres-

sure will be indicated on the gauge marked "air supply" in the instrument. See note in paragraph F-1 below for exceptions.

Each control unit requires 0.4 cubic feet of air per minute. Bristol's reducing valve consumes 0.2 cubic feet of air per minute. Thus, a single control unit with a reducing valve requires 0.6 cubic feet of air per minute. A controller with two control units and one reducing valve uses 1 cubic foot per minute.

F. Supply Air Piping

A typical installation is shown in Figure 2 on page 4. Install the supply air lines to slope away from the controller so that condensed moisture cannot drain into the instrument. Connect the instrument supply air lines to the top of the main air line to prevent condensate from entering.

To avoid trouble from pipe scale or rust which occur in iron pipe, it is recommended that 3/8" O.D. annealed copper tubing and compression fittings, or 1/4" brass pipe be used for both supply air and output air lines. Ream the ends of all tubing to remove burrs. Clean scale, rust, dirt and oil out of all pipe or tubing and blow them out thoroughly with compressed air before installation.

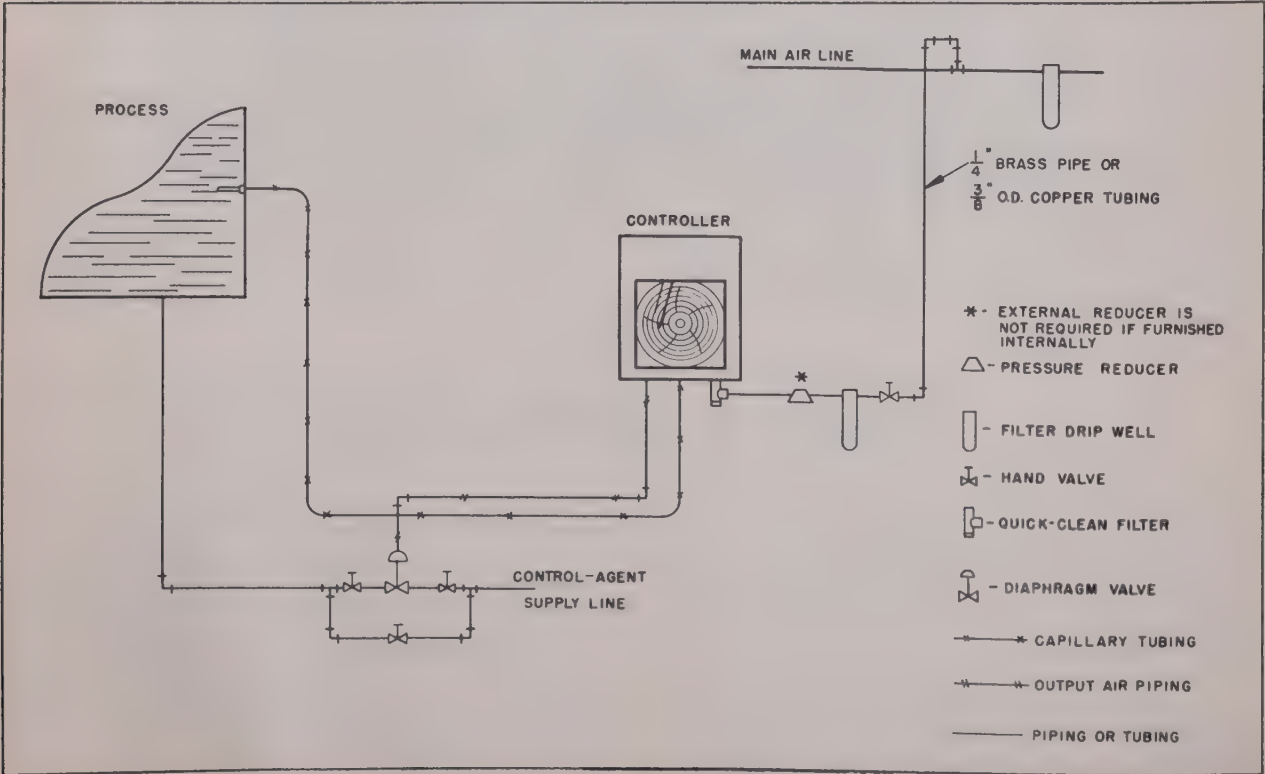


FIGURE 2. TYPICAL INSTALLATION DIAGRAM

1. Reducing Valve. A reducing valve must be used to deliver 20 psi supply air to the controller. Series 500 instruments may be ordered with a Bristol reducing valve installed internally or on an external panel. Series 560 and 565 instruments may be ordered with a Bristol reducing valve externally mounted only. The valve has a capacity of 5 cubic feet of free air per minute. The reducing valve itself consumes 0.2 cubic feet of free air per minute. Maximum air pressure to Bristol's reducer should not exceed 75 psi. Minimum air pressure to reducer must not be less than 25 psi. If a pressure greater than 75 psi must be reduced, install a second reducing valve of a higher pressure rating upstream from the Bristol reducing valve. Leaks in the supply air line will not affect the controller accuracy as long as the supply air gauge in the instrument reads exactly 20 psi.

Note: On all instruments with the numbers CW6, DW6 or EW6 in their model number (such as 1T500CW6, 1G500EW6, etc.) the following exceptions apply:

a. The internal regulator is used only for manual operation of the control valve.

b. The pressure gauge in the lower right corner of the case, normally used to indicate the instrument supply air pressure, is used only to indicate the output air pressure of the internal regulator. The 20 psi air supply to the instrument must therefore be supplied thru an external regulator and gauge.

2. Air-filter Sump. Connect an air-filter sump in the supply line.

3. Manual Shut-off Valve. It is recommended that an inexpensive globe valve be installed in the supply air line, upstream from the reducer, so that the air may be shut off by hand for service to the controller, filter, reducing valve, etc.

G. Output Air Piping

1/4" O.D. copper tubing and compression fittings are recommended for the output air piping on most installations.

Where fast response is a critical factor, 3/8" O.D. copper tubing and compression fittings should be used.

See Figure 2 for typical installation drawing.

H. Control Valve

To obtain linear, proportional control action, the use of an equal-percentage-characteristic final control element is recommended, such as Bristol's equal percentage*, V-port double-seated air-operated control valve. This valve is the most universally applicable type for proportional control and requires less exact sizing for successful control. In general, the control valve should be at least one size smaller than the control-agent pipe. This assures that the largest part of the pressure drop through the control-agent supply system will occur at the control valve. Quick-opening and disk-type valves should not be used where proportional control is desired.

All of Bristol's Series 500W Free-Vane Controllers which have proportional action are designed for use with final control elements which operate from one end of their stroke to the other through output air pressures of 3 to 15 psi as recommended by the Industrial Instruments and Regulators Division of the ASME.

J. Valve-Operation Plate

On the chart plate of each air controller there is a small reversible plate under the output air gauge which indicates the direction in which the control valve operates, i.e., "air to open" or "air to close".

When installing the output air connections to a final control element, check its direction of operation and make sure that the valve-operation plate is correct (the plate is printed on both sides and is reversible).

When using a normally open (direct acting) control valve, the plate should read "air to close", and for a normally closed valve (reverse acting), the plate should read "air to open".

*Equal percentage means that each equal increment of valve-stem travel causes an equal percentage of flow change through the valve.

PART III OPERATION

Do not start the controller until the pen or pointer of the instrument indicates that the measuring system is working

correctly and accurately. See separate instructions covering the measuring system

Note: Numbers appearing in paren-

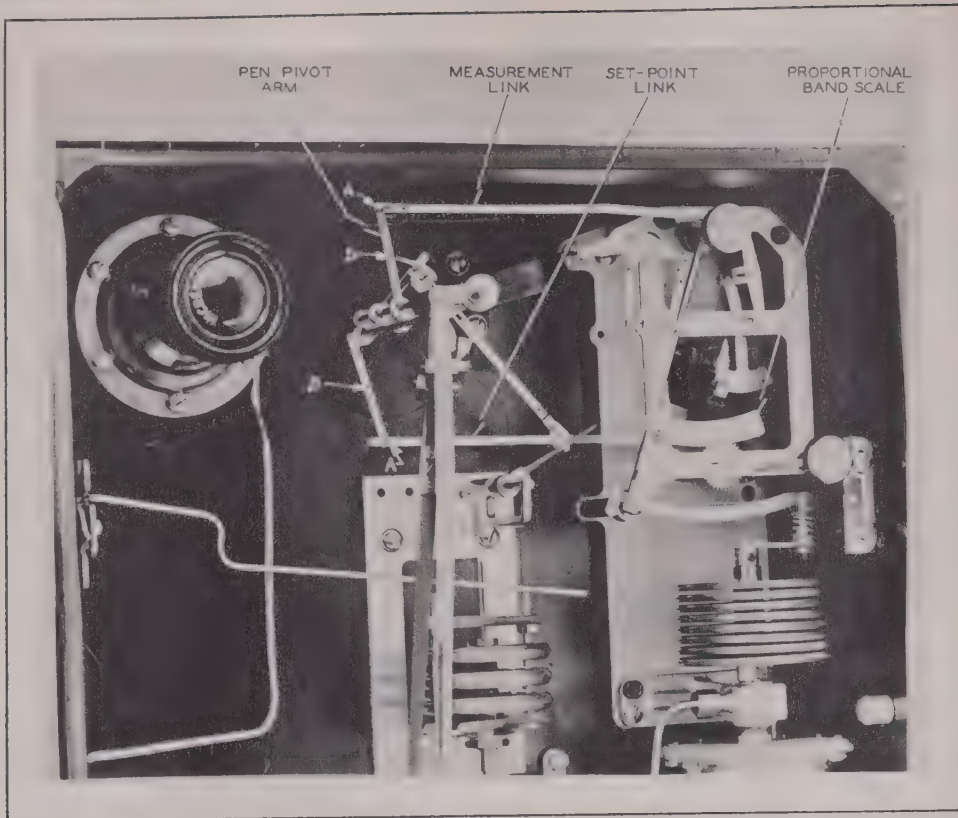


FIGURE 3. UPPER HALF OF SERIES 500W CONTROLLER SHOWING DOUBLE-BAND LINKAGE IN STANDARD BAND (200% PROPORTIONAL BAND POSITION)

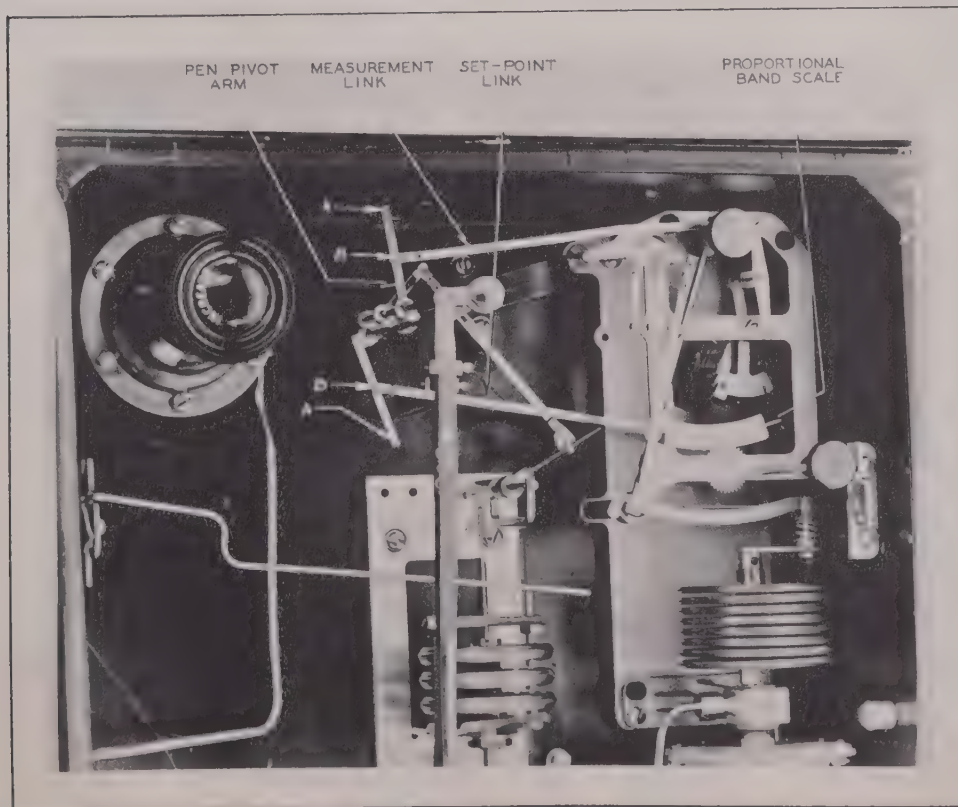


FIGURE 4. UPPER HALF OF SERIES 500W CONTROLLER SHOWING DOUBLE-BAND LINKAGE IN DOUBLE-BAND POSITION (400% PROPORTIONAL BAND POSITION)

theses, such as (Item 20), are a reference to items illustrated in Figure 1 found on page 2.

A. Starting Controllers with Derivative Action Only

Set the proportional band at 50% or greater and the derivative-time knob (Item 26) at zero. Turn on the supply air and adjust the reducing valve until the supply air gauge reads 20 psi. Adjust the set-point index by means of its knob (Item 20) to the desired value on the chart or scale. Turn on the control-agent supply to the process, that is, steam, water, fuel, furnace heat, etc. The process is now under automatic control, and the correct proportional band and derivative time may be determined as soon as the process has come up to the control point.

1. Adjusting the Proportional Band.

Narrow the proportional band in small steps, such as from 50% of the band scale to 30%, to 20% to 15% to 10%. If normal load changes to the process are too small or too infrequent during this adjustment period, the effect of load changes can be artificially produced by shifting the set-point index upscale and downscale about 1/8 inch from the value at which the controller will be used. Allow plenty of time between each change in the proportional band for the full effect of the adjustment to be observed on the chart record. In general, the narrowest proportional band that will not produce objectionable cycling gives the best control.

2. Adjusting the Derivative Time.

Turn the derivative-time knob (Item 26) from zero to 0.2. Again, produce small load changes by shifting the set-point index 1/8 inch upscale and downscale from the desired value. Increase derivative time step by step. After each change in derivative time, wait for the effect of the change to show up on the chart record. The purpose of derivative action is to stabilize control on a relatively difficult process. Thus, the best derivative adjustment must be found for each different application. After the correct derivative adjustment has been found for the particular process, again try narrowing the proportional band a little. The addition of derivative action usually permits use of a narrower proportional band. Derivative action should not be used on an easy to control single-capacity process.

B. Manual Start-up of Controller with Reset Action Only

Controllers having reset action are often started under manual control in order to avoid serious overshooting caused by reset action during start-up.

1. Manual Start-up with a Manual-Automatic Valve. (For controllers using external manual-automatic stations, see separate instructions furnished with these stations.) To start up under manual control with instruments equipped with a manual-automatic valve (Item 1), turn the manual-automatic valve to the manual position, set the proportional band at 50% or more, set the reset rate at the 0.1 position and adjust the pressure regulator (Item 9) so that it will close the control valve. Whether the final control element (control valve) will require a zero or a 20 psi output pressure to close depends on its direction of action, that is, normally closed or normally open. The valve-action direction plate on the output air pressure gauge will give the information.

Turn on the control agent supplied to the process and slowly open the control valve to its usual operating position by adjusting the pressure regulator. Continue to control the process manually until stable control is accomplished. This can be determined by watching the chart record.

Now, turn the set-point-index knob (Item 20) so that the set-point index agrees exactly with the pen or pointer. Turn the manual-automatic valve to the automatic position. Immediately adjust the pressure regulator to give 20 psi on the supply air gauge. Adjust the set-point index to the desired value on the chart.

2. Selecting the Proportional Band.

Unless otherwise stated the Reset controllers are shipped with the linkage in the 200% proportional band position, as shown in Fig. 3. The selection of which proportional band to use is up to the user, and conversion from one to the other is easily accomplished in the field with no extra parts and no recalibration required.

a. How to change from 200% to 400% proportional band width. Change measurement link and set-point link to positions shown in Fig. 4. This change can be made in a few minutes with only the aid of a small screw driver. The

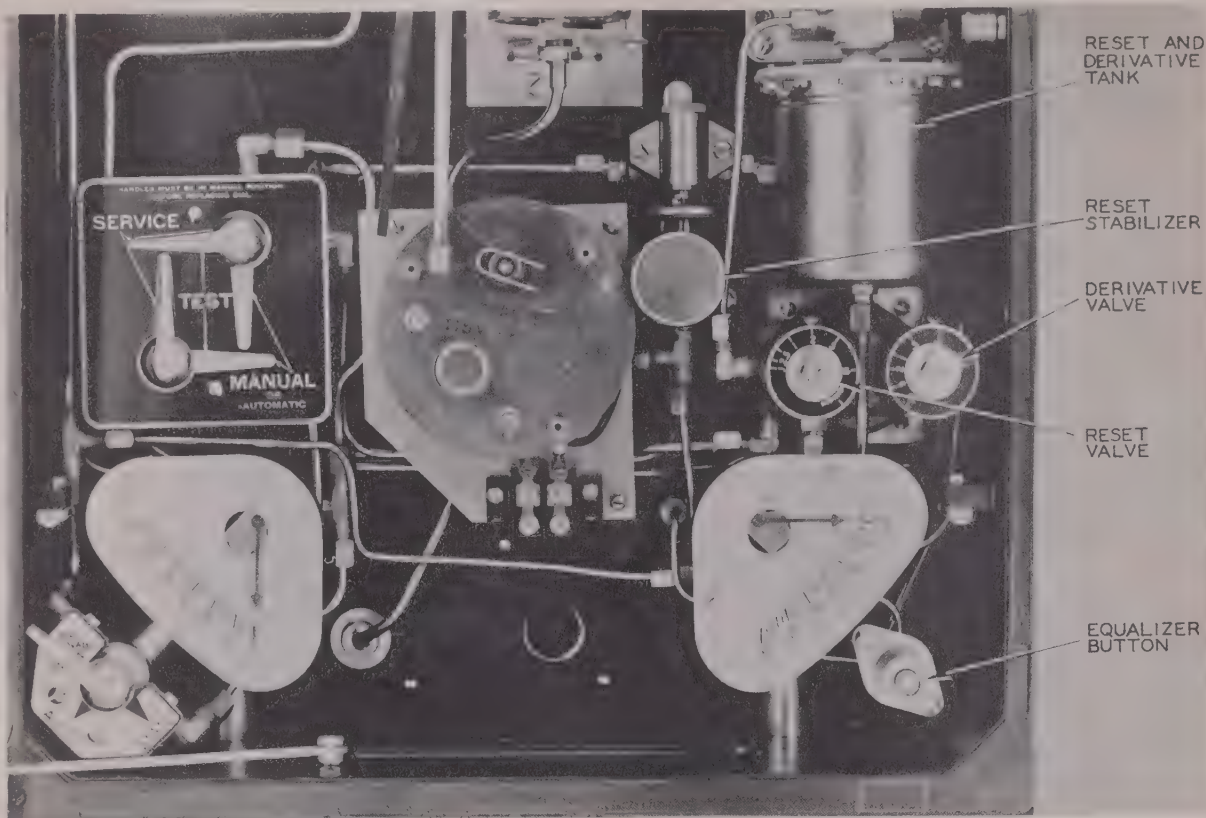


FIGURE 5. LOWER HALF OF SERIES 500W CONTROLLER SHOWING LOCATION OF THE PILOT VALVE, RESET STABILIZER AND RESET AND DERIVATIVE VALVES

400% band width positions are indicated by green paint.

No alteration in the marking of the band scale is made, but when in the double-band position the band-scale reading is doubled. For example: in the double-band position and a scale reading of 150, the instrument is operating with a proportional band of 300%.

b. How to change from 400% to 200% proportional-band width. Change measurement link and set-point link to positions shown in Fig. 3.

3. Adjusting the Proportional Band. Adjust the proportional band as described in paragraph A-1 page 7.

4. Adjusting the Reset Rate. Turn the reset-rate lever (Item 27) from 0.1 to its 0.2 position. Wait for the change in reset rate to show up on the chart record. The setting of the reset rate will depend on the control characteristics of the individual process and must be determined by slowly adding more reset, one step at a time, until the best control is obtained. In general, use the

fastest reset rate that can be applied without increasing instability.

5. Using Zero Reset Rate. You may need to use a reset controller with proportional action only for such purposes as the following:

- a. Checking rocker-arm adjustment if feedback bellows is replaced.
- b. Checking for leaks in reset system.
- c. Checking width of proportional band.
- d. Laboratory testing of controller actions and adjustments.
- e. Demonstration in instrument training courses, etc.

NOTE: Before turning reset lever to zero on the reset scale, you must do the following:

- 1st. Be sure air supply is exactly 20 psi.
- 2nd. Set proportional band to 10%

of band scale and derivative knob (Item 26) to zero on its scale.

3rd. Set reset knob (Item 27) to its fastest rate.

4th. The pen or indicating pointer must be held absolutely motionless during the next step. This can be done on recorders by disconnecting the pen from the measuring element at the lower end of link (Item 8) and by punching the pen point thru the chart paper. The pointer of indicating instruments can be held still by fastening it to the scale with a paper clip. On Dynamasters, the pen can be held motionless by turning off the power switch.

5th. Now, adjust the set-point-index knob so as to get and hold 9 psi output air pressure on gauge (Item 2). Continue to hold 9 psi output air pressure for 5 minutes. This will allow the feedback and reset bellows to bleed to exactly atmospheric pressure.

6th. After 5 minutes at 9 psi output air pressure, turn reset knob to its minimum position. The controller now will operate as a proportional controller with its set-point index exactly in the center of its proportional band. Any tests or adjustments described above (a thru e) can now be made.

CAUTION: Do not use zero reset rate for normal control because, with reset valve closed, case ambient-temperature changes will cause the control point of the control unit to shift. Even if the process being controlled required no reset for satisfactory control, always use at least the slowest reset rate (0.1 position) for normal control.

C. Manual Start-up of Controllers with Reset Plus Derivative Action

1. Manual Start-up with a Manual-Automatic Valve. The procedure for starting reset plus derivative controllers is exactly the same as that for reset controllers (as explained in paragraph B above) except that the derivative time is determined before the reset rate is established. This is done by moving the derivative knob from zero upscale one step at a time. Between each derivative adjustment, pause long enough to allow the process to stabilize and then determine the results by observing the chart record. The best derivative setting is that which gives the most stable control following sudden load changes. After the correct derivative time has been found, again

try narrowing the proportional band a little.

Next, adjust the reset rate as per paragraph B-4 above.

D. Starting Controllers with Internal Manual-Automatic Accessories

Instruments equipped with internal manual-automatic accessories are furnished with instructions on a decal pasted on the inside of the instrument door. These instructions are repeated below:

1. Conditions for automatic control

a. 20 psi on supply air gauge (lower right). See note in paragraph Fig. 1, Part II for exceptions.

b. Test and service valves in manual-automatic position.

c. Manual-automatic valve in automatic position.

2. Changing from automatic to manual control

a. Push equalizing button momentarily to note the output air pressure of the instrument on the right-hand gauge.

b. Adjust regulator so that its output air pressure (right-hand gauge) is such that the gauge pointer does not move when the push button is depressed.

c. Turn manual-automatic valve to the manual position. The control valve may then be positioned by adjusting the pressure regulator. **Note:** The left-hand gauge always indicates the air pressure on the control valve.

3. Changing from manual to automatic control

a. Test and service valves must be in the manual-automatic position. Allow sufficient time under this condition for a reset controller to balance. Proportional and derivative controllers will balance almost instantaneously and therefore do not require a waiting period.

b. Adjust set-point index to coincide with pen or pointer.

c. Turn manual-automatic valve to the automatic position. Control valve is then under automatic control.

E. Stopping the Controller

1. Temporary Shutdown. Move the set-point index in a direction (usually toward zero) that will shut down the process.

2. **Prolonged Shutdown.** Turn off the control-agent supply to the process. Turn off the air supply to the controller.

F. Changing Direction of Controller Action

A direct-acting air controller **increases** output air pressure as the pen or pointer goes upscale. A reverse-acting controller **decreases** the output air pressure as the pen or pointer goes upscale.

It is sometimes necessary to change the direction of action of an air controller to adapt it to changed process requirements or to use it with a control valve of opposite action.

To change the direction of controller action from direct to reverse, or reverse to direct, it is only necessary to shift the position of the vane positioning arm (Item 30) from one notch to the other and to move the reversing link (Item 12) to the opposite arm of the reversing tee lever (Item 13).

Hold the vane reversing lever and move the vane positioning arm until it snaps into the other notch. This shifts the position of the vane so that its opposite edge moves between the nozzles.

Now, shift the position of the reversing link (Item 12), to the opposite arm of the reversing tee lever. To disconnect the link, swing the tab aside.

PART IV SERVICE

In discussing service and maintenance, we assume that the measuring system of the controller is working properly. If not, repair it before attempting to service the control system.

To facilitate service on Free-vane controllers, The Bristol Company can supply, on order, a small kit of tools (Part No. 67740).

A. Routine Maintenance

1. **Air-filter Sump.** Moisture, oil and dirt which collect in the bottom of the air-filter sump should be drained out daily. Open the drain valve for a few seconds with the supply air turned on.

2. **Quick-clean Air Filter.** The Quick-clean air filter should be cleaned periodically, as often as experience shows it to be necessary. To clean the filter, turn off the supply air, unscrew the plug at the bottom, remove the disk unit, separate the disks, rinse them in carbon tetrachloride and gently blow them off with compressed air. Reassemble and tighten the plug firmly.

3. **Lubrication.** No lubrication of any sort is required in any of Bristol's Series 500W Air Controllers. If the bearing become sticky, clean them with carbon tetrachloride.

B. Trouble Shooting

Unless there is an obvious fault in the air controller, a thorough check of the process, measuring system, and final control element should be made first.

The following check list can be used as a guide for the systematic search for possible trouble in the air controller:

1. **Symptom.** Output air pressure (as shown on the output air gauge) is continuously high, regardless of the position of the set-point index, pen or pointer.

Possible Faults. Nozzle back pressure is too low because of a leak in the nozzle assembly or tubing; the pilot-valve orifice is plugged; the pilot-valve ball is not seating properly.

2. **Symptom.** Output air pressure (as shown on the output air gauge) is continuously low, regardless of the position of the set-point index, pen or pointer.

Possible Faults. Control-valve diaphragm is punctured; the output air line leaks; the nozzle back pressure is too high because of plugged nozzles or a loose orifice plug; the pilot-valve ball is not seating properly.

3. **Symptom.** (with reset action). Slow reset rate cannot be obtained or resetting occurs even with reset valve closed (turned fully clockwise).

Possible Fault. Leak in the feedback bellows (Item 23), reset valve or in the connections to the reset valve block. A test procedure for this trouble is given in paragraph D, page 11.

4. **Symptom.** (with reset action). Feedback bellows remains extended to its full length, regardless of changes in output air pressure.

Possible Fault. Leak in the reset bellows (Item 24). A test procedure for this trouble is given in paragraph D, page 11.

CAUTION: A leak in the reset bellows will cause damage to the feedback bellows if the supply air to the instrument is not turned off immediately.

5. Symptom. (with derivative action). A change in the control point when the derivative time is switched from zero to any other value. This is best observed when the measured variable is in a steady state, i.e., the pen is recording in a straight line.

Possible Fault. Leaks to atmosphere in the derivative or reset tank (See Fig. 1), feedback bellows, derivative valve block (See Fig. 6) or connections from valve block to derivative or reset tank. (See paragraph E below for testing for leaks in the derivative system).

C. Testing for Leaks in Tubing

Any air leaks in the nozzle air system or output air system will cause incorrect control. Test for leaks by applying a soapy-water solution to all joints, unions, screw plugs and caps while the air is on. Bubbles will form at any leaking point. Leaks in the supply air system will not affect control accuracy as long as the supply air gauge indicates 20 psi but leaks will waste compressed air.

D. Testing for Leaks in Feedback and Reset Bellows

Very small leaks in the feedback bellows, reset bellows, or their connections will cause serious effects in proportional, reset and derivative actions. To check for leaks, follow this procedure

1. Set reset lever (Item 27) to zero in the manner outlined in paragraph 4, page 8 under "Using Zero Reset Rate".

2. Adjust set-point-index knob to give 11 psi on output air gauge (Item 2) If there are no leaks, the output air gauge should remain steady at 11 psi.

3. If the output air pressure slowly **increases**, it indicates a leak in the feedback bellows, reset valve, or their connections. The leak can be found by applying a soapy-water solution and noting bubbling.

4. If the output air pressure slowly **decreases**, it indicates a leak of output air thru the reset bellows into the reset air system. In this case, the reset bellows must be replaced. If this leak is large, enough output air will enter to rupture the feedback bellows, which will necessitate the replacement of both bellows.

E. Testing for Leaks in the Derivative System.

The pen must be steady for this test. If it is not steady, unhook one end of measuring element link (Item 8) and push the pen nib thru the chart to hold the pen fixed. Close reset valve (clockwise) and open derivative valve (counterclockwise). If necessary, adjust set-point index to bring output pressure to some value between 3 and 15 psi. The output should be steady, because pen and set-point index are fixed and reset valve is closed. Now close the derivative valve to 20. If the output now climbs to a new value, there is a leak to atmosphere somewhere in the derivative valve block, in the reset or derivative tank, in the connections from the block to the tank or in the feedback bellows of a proportional plus derivative controller. Apply a soap solution at these points to find the leak. Check carefully with soap solution the end of by-pass valve stem (See Fig. 6) and the two ball seals on the side of the casting. Even small leaks at these points will seriously affect the derivative response. If the leaks cannot be found, the controller will still function properly without the derivative response provided the derivative valve is opened wide. If soap solution is applied to the bottom plate of the valve pedestal some

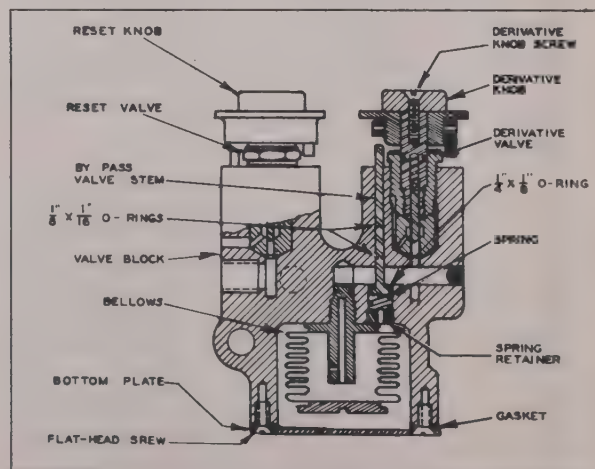


FIGURE 6. CUTAWAY VIEW OF RESET AND DERIVATIVE VALVE PEDESTAL

foam may appear. This small leakage, however, will do no harm as it occurs on the pilot valve side of the derivative valve.

Under the derivative knob is a cam which acts to depress the by-pass valve stem when the derivative valve is in the open position. The depressed stem opens a valve which completely by-passes the derivative needle valve. The cam height is set so it will depress the by-pass valve stem in the open position. The cam acts as a stop when the derivative valve is closed. The cam is held in place by two setscrews.

To replace the bellows in the valve pedestal, it is first necessary to remove the pedestal from the instrument case. Then remove the bottom plate, unscrew the bellows and withdraw it. The by-pass valve stem can be inspected or replaced by removing the spring retainer and spring located on the inside of the pedestal and then pushing the valve stem out by pushing thru from its outside end.

F. Cycling Caused by Control Valve

1. **Friction and Lost Motion.** Cycling control can be caused by mechanical hysteresis or backlash in the final control element or power unit. A sticking control valve will usually produce a cycling chart record of small, uniform amplitude with a distinct time interval between each cycle. Control valves, pneumatic operators, hydraulic cylinders and other final-type control elements and power units must be correctly lubricated and adjusted periodically to eliminate friction and lost motion.

2. **Wrong Control-valve Size.** In general, the control valve should be one size or more smaller than the control-agent pipe. This assures that the largest part of the pressure drop through the control-agent supply system will occur at the control valve.

Control valves (or other final control elements) should never be completely closed or opened by the controller except during the start-up of the process. During normal operation, a valve that is almost always closed is obviously too large, and a valve that is almost always wide open is too small. A control valve is too small only if it cannot pass enough control agent, when wide open, to maintain the variable at the desired value under full load on the process.

G. Oscillation Caused by Small Output Air System Volume

If the total volume of the output air system (including the volume of the output air piping and volume of the final control element such as a valve top) is small enough, oscillation of the air control unit can occur. A rapid, continuous pulsating or pumping pressure on the output air gauge (Item 2) indicates this condition.

Control-unit oscillation occurs only when the volume of the output air system is very small, as when output air lines are short and a valve positioner is used. The tendency to oscillate increases as the proportional-band width is increased.

When such oscillating occurs, the volume of the output air system must be increased to approximately 50 cubic inches. This is easily done by connecting a capacity tank into the output air piping close to the controller. Such a tank can be made from a length of 2" pipe capped at both ends and tapped to take a T fitting.

H. Cleaning the Pilot-valve Orifice

(See Fig. 7) Remove the orifice screw cap, being careful not to lose the gasket. With a #10 6-spline Bristo wrench (included in the Free-vane tool kit), remove the brass orifice plug. Clean the hole in the plug with a fine wire (included in tool kit) and carbon tetrachloride. Replace the plug, gasket and screw cap.

J. Cleaning the Nozzles

Remove the measuring-element linkage so that the vane may be completely withdrawn from between the nozzles. Remove the nozzle screw cap from the nozzle assembly, being careful not to lose its gasket. With the supply air on and the vane out of the nozzles, insert a cleaning wire through the front nozzle, across the gap and through the rear nozzle. Work the wire in and out to free any dirt which will be carried out by the air pressure. Replace the nozzle cap and gasket.

CAUTION: Be very careful not to damage the vane; it must pass freely between the nozzles without touching either one.

K. Cleaning the Nozzle Tubing

It may be necessary to clean out the tubing between the pilot valve and the

tubing between the pilot valve and the nozzles. If so, first turn off the supply air. Remove the pilot-valve orifice screw cap and inject 20 to 30 drops of carbon tetrachloride into the opening (use an eyedropper). Replace the orifice screw cap and gasket. Turn on the supply air. The air pressure will force the carbon tetrachloride through the tubing and out through the nozzles, dissolving any oil. Repeat this if necessary.

L. Cleaning the Pilot Valve

(See Fig. 7) Remove the two screws which hold the valve body to the valve mounting. Pry the valve body loose. Loosen the lock nut on the bottom of the valve body and unscrew the lower valve seat. Be careful not to lose the tiny valve ball which may drop out of the rear of the valve body. Remove the hex cap, spring and upper valve stem, and clean all valve parts in carbon tetrachloride. Reassemble as per Fig. 7, making sure that the barb on the lower valve stem is up (so that it won't fall thru the lower valve seat). Before attaching the valve body to the mounting, adjust the seat clearance as described in paragraph P page 14.

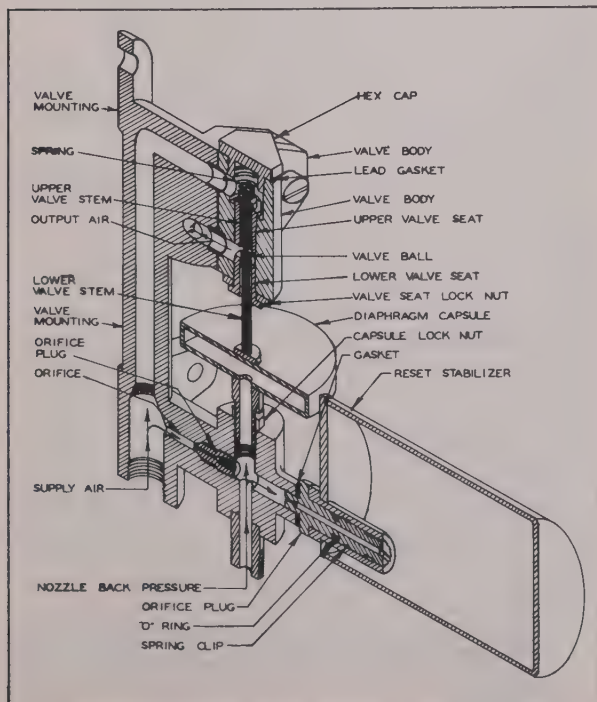


FIGURE 7. CUTAWAY VIEW OF PILOT VALVE AND RESET STABILIZER

M. Cleaning the Reset and Derivative Valves

The reset and derivative needle valves have been assembled and checked at the factory. The valve stem and its body should always be used as a pair.

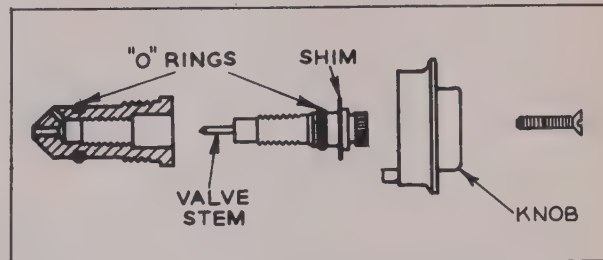


FIGURE 8. NEEDLE VALVE DISASSEMBLED

The needle valve may be removed for cleaning. (See detailed assembly drawing Fig. 8). To remove the needle section of the valve, first remove the holding screw; then lift the knob from the splined stem and turn the stem all the way out until it is disengaged from the body. These needle valves are of the spring-release type, as a safeguard against damage. Note that an "O" ring is provided on the stem to prevent leakage, and shims are used to space the stem for proper operation. Use an open-end wrench when removing the valve body. An "O" ring is also supplied on the body to prevent leakage.

For cleaning, use carbon tetrachloride or a similar solvent.

In reassembling the valve, screw the body firmly into the pedestal and turn the valve stem in tightly. Reset the knob on the stem with the stop pin of the knob against the stop of the pedestal; then tighten the holding screw.

For identification, "standard" reset valve parts are stamped "RF", the "fast" reset valve parts are stamped "T", and the derivative valve parts are stamped "R".

N. Reset Stabilizer

The reset stabilizer consists of a restriction and volume tank mounted on the pilot valve at the connection used for testing the back pressure. The purpose of the reset stabilizer is to prevent cycling in the internal feedback loop.

This unit has no effect on the steady-state value of the back pressure from the vanes and nozzles; and will not affect the maximum values of this back pressure, and therefore does not affect the proportional band values.

Nozzle Back Pressure on Test Gauge When			
Set-Point Index is above pen		Set-Point Index is below pen	
Direct Acting Control	Reverse Acting Control	Direct Acting Control	Reverse Acting Control
9 - 12 psi	$2\frac{1}{4}$ - $2\frac{3}{4}$ psi	$2\frac{1}{4}$ - $2\frac{3}{4}$ psi	9 - 12 psi

To remove the reset stabilizer simply pull the tank off and then remove the orifice screw plug with a screw driver.

P. Pilot-valve Seat Clearance

The pilot-valve ball should have a vertical travel between the upper and lower seats of .010 inch. To check this clearance, loosen the valve-seat lock nut. Gently screw the lower valve seat in until the ball is held firmly between the upper and lower seats. This can be seen through the back of the valve body. Now back out the lower seat **three** faces of its hex nut. This adjustment gives the correct clearance of .010". Tighten the lock nut.

Q. Checking the Nozzle Back Pressure

The nozzle back pressure bears a very definite relation to the position of the vane between the nozzles, and this, in turn, governs the output air pressure. To check the nozzle back pressure, remove the reset stabilizer tank and orifice screw plug and screw in a 0-30 psi test gauge (one is included in the standard tool kit). Be sure to use the orifice-screw-plug gasket with the test gauge to avoid leakage.

Turn on the supply air. Turn the proportional band to zero, the reset rate and derivative time to zero and adjust the reducing valve to give exactly 20 psi on the supply air gauge (Item 28).

Move the vane completely out from between the nozzles by moving the set-point index below the pen or pointer. The nozzle back pressure for a direct acting controller, as measured by the test gauge, should be $2\frac{1}{2}$ psi (plus or minus $\frac{1}{4}$ psi). When the vane is moved completely into the nozzles (by moving the set-point index above the pen or pointer), the back pressure should be not less than 9 psi and not more than 12 psi. When the test gauge reads 5 psi back pressure, the output air gauge of the controller should read 9 psi. These conditions are summarized in the table on page 14 for both direct and reverse acting controllers:

If the nozzle back pressures do not

test correctly, the orifice or nozzle system may be plugged or leaking. See paragraphs C, H, J, K and L.

R. Checking and Adjusting the Relation between the Nozzle Back Pressure and Output Air Pressure

Connect the 0-30 psi test gauge to the pilot valve (as in paragraph M above) and disconnect the link from the measuring element so that the pen will be absolutely stationary. Punch the pen through the chart to keep it steady. The supply air pressure must be exactly 20 psi.

Adjust the proportional band to 10% of band scale, the reset rate to zero and the derivative time to zero.

Adjust the set-point index until the nozzle back pressure on the test gauge is 5 psi. The output air gauge should now read 9 psi. If it does not read exactly 9 psi, adjust the height of the pilot-valve capsule by loosening the lock nut and turning the capsule up or down to get a pressure of 9 psi on the output air gauge. Be sure to retighten the lock nut.

S. Removing, Cleaning and Replacing the Free Vane

If the supply air is not kept clean and dry, the vane may become dirty and gummed with oil. It can be removed for cleaning or replacement. Disconnect the link to the vane lever. Loosen the vane shaft-bearing lock nut (Item 15) slightly. Hold the vane assembly so that it is clear of the nozzles, and unscrew the bearing screw until the vane assembly and differential lever are free. Remove them as a single unit. Clean the entire assembly with carbon tetrachloride. Replace the parts and adjust the bearing screw to allow noticeable end play in the vane shaft. Tighten the lock nut and reconnect the linkage.

T. Checking or Adjusting the Rocker Arm (Arcing Lever) on Derivative Controllers

The rocker arm has been very accurately adjusted at the factory and should

never require further adjustment unless the feedback bellows has been subjected to excessive pressure or is being replaced.

1. The pen or pointer must be absolutely stationary all during this check or adjustment. This can be done on recorders by disconnecting the pen from the measuring element at the lower end of link (Item 8), and by punching the pen point thru the chart paper. On indicators, the pointer can be held still by fastening it to the scale with a paper clip. On Dynamasters, the pen can be held motionless by turning off the power switch.

2. Adjust the supply air pressure regulator to show exactly 20 psi on the supply air gauge.

3. Set the proportional band to 10% of band scale and set the derivative time to zero.

4. Move the set-point index until the output air gauge reads exactly 9 psi.

5. Now move the proportional-band adjustment (Item 14) thru its full travel from one end of the scale to the other and, at the same time, watch the output air gauge (Item 2). If the rocker-arm adjustment is correct, the output air pressure should not change as the proportional band is changed between 5% and 100% of band scale.

6. If the output air pressure changes from 9 psi, turn the rocker-arm adjusting nut (Item 22) until the output air pressure remains constant at 9 psi while the proportional band is changed between 5% and 100% of band scale.

7. After adjustment, reconnect the link to the measuring element.

U. Checking or Adjusting the Rocker Arm on Reset or Reset Plus Derivative Controllers

The rocker arm has been very accurately adjusted at the factory and should never require further adjustment unless the feedback bellows has been subjected to excessive pressures or is being replaced.

1. Set reset lever to zero in the manner outlined in paragraph 4, page 8 under "Using Zero Reset Rate".

2. While continuing to hold the 9 psi output air pressure, turn the proportional-band knob thru its full travel. If the output air pressure changes from 9

psi, turn the rocker-arm adjusting nut (Item 22) until the output air pressure remains constant at 9 psi while the proportional band is being changed from 5% to 100% of band scale.

V. Set-point-index Calibration

The calibration of the measuring system is discussed in separate instructions. Whenever a new measuring system is installed or the old one recalibrated or otherwise changed, the set-point-index adjustment must be checked.

1. The pen or pointer must be absolutely stationary. On recorders, disconnect the pen from the measuring element at the lower end of link (Item 8) and punch the pen point thru the chart paper. On indicators, the pointer can be held still by fastening it to the scale with a paper clip. On Dynamasters, the pen can be held motionless by turning off the power switch.

2. Adjust the supply air pressure regulator to show exactly 20 psi on the supply air gauge.

3. Set proportional band to 10% of band scale.

4. Set derivative time to zero.

5. Set reset rate to 9.

6. Move set-point index so that the output air gauge (Item 2) reads 9 psi. The set-point index should be at exactly the same value as the pen or pointer. If not, turn the microadjustment (Item 10) on the set-point-index arm until it agrees with the pen or pointer. On Dynamasters, the set-point index may be adjusted by first loosening the thumb screw, clamping the set-point index to the gut or cord and then shifting the index to the right or left as required. Retighten thumb screw after adjustment.

7. After adjustment, reconnect the link to the measuring element.

CAUTION: Never turn the pen or pointer microadjustment except when calibrating the measuring system.

W. Repairs, Correspondence and Shipping

It is especially important, when writing to The Bristol Company regarding air controllers, to include one or two sample charts which illustrate the difficulty encountered. Indicate by writing on these sample charts the points at which load changes occurred and the points where set-

point changes were made. Such chart records will give The Bristol Company much information on the controller and the process, and help to analyze and remedy the difficulty.

Send all correspondence and orders to the nearest Branch Office. Send parts and controllers for repair or replacement to

the Branch or Main Factories only, not to the Branch Offices. Addresses will be found on the last page of this book.

Be sure to identify your shipment fully, including exact return address, model and serial number of controller, your order number, etc.

The Bristol Company
Waterbury 20, Connecticut

Printed in U.S.A.

SERIES 500 FREE-VANE® RESET AND RESET-PLUS-DERIVATIVE ACTION CONTROL UNIT

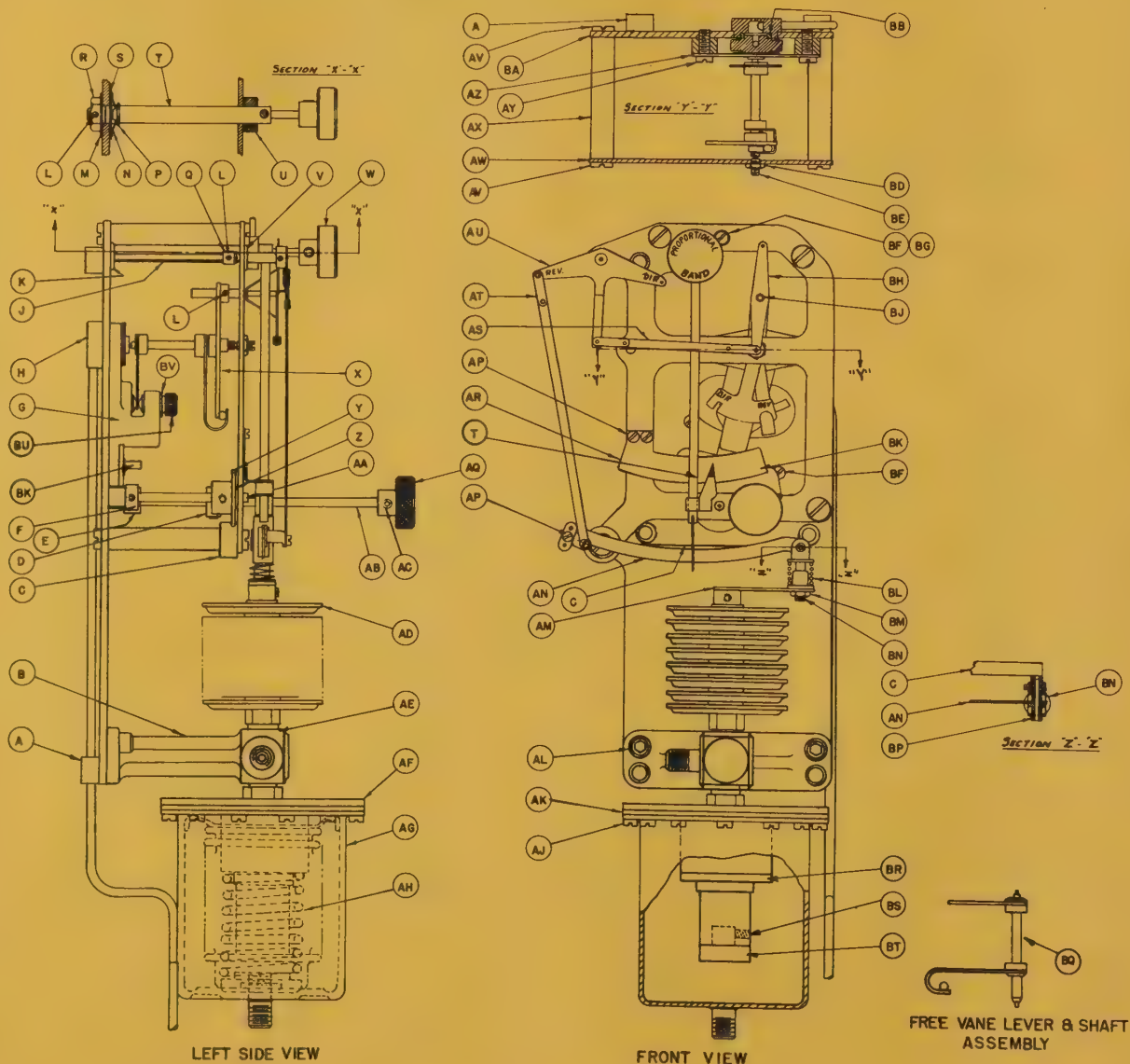


ILLUSTRATION - RIGHT-HAND RESET AND RESET-PLUS-DERIVATIVE ACTION CONTROL UNIT

BE SURE TO STATE MODEL & SERIAL NUMBER OF INSTRUMENT WHEN ORDERING PARTS

DESCRIPTION	PART NO.
NOTES: 1. Although the illustration on Page 1 shows a right-hand control unit, no difficulty should be encountered in identifying parts for a left-hand unit because all parts are interchangeable between right- and left-hand units except where noted below. 2. Dynamaster and time-program control units are the same as the illustration on Page 1 except for the removal of the set-point-index knob, shaft, etc., and the addition of those parts listed under not shown items on Page 4. 3. Reference below to a 26.5° chart means a chart whose inner circle is small and one that may be identified by a chart number having 5 digits, such as 55000, 12000, etc. A 22.3° chart has a large inner circle and may have 4 digits or less in its number, such as 851, 4811, 0581, etc. 4. A standard chart is one in which the chart values increase as the pen goes from the inner to the outer circle of the chart. A reverse chart is one in which the chart values increase as the pen goes from the outer to the inner circle of the chart. 5. Master Controller is the title given to a reset controller whose output pressure (0-20 psi) is used to position the set point of an Autotest controller. These control units are made up without reset stops items BR and BT.	
CONTROL UNITS COMPLETE	
FOR 12" 500 SERIES RECORDERS	
Right-hand unit (26.5° standard chart instruments)	86900
Right-hand unit (26.5° reverse chart instruments)	86080
Right-hand unit (22.3° standard chart instruments)	90797
Right-hand unit (22.3° reverse chart instruments)	96079
Left-hand unit (26.5° standard chart instruments)	86992
Left-hand unit (26.5° reverse chart instruments)	96086
Left-hand unit (22.3° standard chart instruments)	90796
Left-hand unit (22.3° reverse chart instruments)	96085
Right-hand unit in a reset master controller (26.5° chart)	89946
Right-hand unit in a reset master controller (22.3° chart)	89947
FOR 12" 500 SERIES INDICATORS	96080
FOR 12" 500 SERIES TIME-PROGRAM CONTROLLERS	
Right-hand unit (26.5° standard chart instruments)	93570
Right-hand unit (22.3° standard chart instruments)	93571
Left-hand unit (26.5° standard chart instruments)	93572
Left-hand unit (22.3° standard chart instruments)	93573
FOR 560 AND 565 SERIES DYNAMASTER CONTROLLERS	91221

BE SURE TO STATE MODEL & SERIAL NUMBER OF INSTRUMENT WHEN ORDERING PARTS

ITEM	DESCRIPTION	PART NO.
A	Bushing for mounting holes	78746
B	Bellows support bracket complete: For all right-hand units in recorders and time-program controllers	86481
	For all left-hand units in recorders and time-program controllers	88292
	For indicators	86481
	For Dynamasters	86481
C	Diaphragm flexure arm complete for feedback bellows	86945
D	Set-point-shaft pinion gear (12T-32P) in recorders and indicators	53490
E	Set-point-shaft collar in recorders and indicators	86461
F	Counter-shaft pinion gear (8T-32P) in recorders and indicators	86406
G	Jet arm and gear segment complete, with nozzle cap and gasket: For all recorders and indicators	86477
	For Dynamasters and time-program controllers	91223
H	Tubing connection complete: For all right-hand units in recorders and time-program controllers	86965
	For all left-hand units in recorders and time-program controllers	86443
	For all indicators	86965
	For all Dynamasters	91240
J	Shaft for follow-up reversal lever	86959
K	Rear bearing bushing for Item J	80835
L	#2-64 x 3/16" Slotted setscrew	23748
M	Washer	29414
N	Spring washer	67384
P	Bearing bushing for proportional-band-adjustment shaft	86976
Q	Collar for reversing lever shaft	16357
R	Tension nut for proportional-band-adjustment shaft	86977
S	Washer	49971
T	Proportional-band-adjustment shaft, arm and pointer complete: For all right-hand units in recorders and time-program controllers	86925
	For all left-hand units in recorders and time-program controllers	86993
	For indicators	86925
	For Dynamasters	86925
U	Proportional-band-adjustment stop arm complete	86927
V	Front bearing bushing for reversing lever shaft	80827
W	Proportional-band knob	86950
X	Vane positioning arm complete: For all right- and left-hand units (standard chart instruments)	86935
	For all right- and left-hand units (reverse chart instruments)	89997
	For indicators	89997
	For Dynamasters	89997
Y	Counter shaft spur gear (36T-48P)	45317
Z	Spring washer	44870
AA	Counter shaft	75506
AB	Set-point shaft: All right-hand units	86407
	All left-hand units	89967
	All indicators	86407
AC	Setscrew for knobs and gear hubs (Bristo #6-40 x 1/8" flat point)	82403
AD	Feedback bellows	86981
AE	Gasket	53362
AF	Cup cover and abutment complete	86971
AG	Cup complete (includes reset bellows)	86974
AH	Spring for reset bellows	86480
AJ	#6-40 x 1/4" Fillister-head screw	39770
AK	Gasket for cup	54565
AL	#10-32 x 3/8" Hex-cap screw	86384
AM	Bellows arm complete	86948
AN	Rocker arm	86958
AP	#2-64 x 3/32" Fillister-head screw	62795
AQ	Set-point knob (red for right-hand units and indicators)	85701
	Set-point knob (blue for left-hand units)	79350
AR	Proportional-band-width scale plate: For all right-hand units (26.5° standard & reverse chart instruments)	86466
	For all right-hand units (22.3° standard & reverse chart instruments)	90791
	For all left-hand units (26.5° standard & reverse chart instruments)	89776
	For all left-hand units (22.3° standard & reverse chart instruments)	90790
	For all indicators	86466
	For all Dynamasters	86466
AS	Connecting link complete	86985

BE SURE TO STATE MODEL & SERIAL NUMBER OF INSTRUMENT WHEN ORDERING PARTS

ITEM	DESCRIPTION	PART NO.
AT	Reversing link complete	86983
AU	Follow-up reversal lever complete:	
	For all left- and right-hand units (standard chart instruments)	86942
	For all left- and right-hand units (reverse chart instruments)	89994
	For indicators	89994
	For Dynamasters	89994
AV	#6-40 Shoulder screw	86489
AW	Upper bearing plate	86902
AX	Post	86960
AY	#6-40 x 3/8" Fillister-head screw	18329
AZ	Bridge plate complete	86939
BA	Mounting plate	86901
BB	Gasket	52496
BD	#6-40 Hex nut	13775
BE	Vane-shaft-bearing screw (#6-40)	86937
BF	#6-40 x 1/8" Special-head screw	40747
BG	Washer	28211
BH	Differential lever	86910
BJ	Bearing stud for above	86952
BK	Bearing stud for set-point link connection:	
	For all right-hand units in recorders	86963
	For all left-hand units in recorders	86964
	For all indicators	86963
BL	Spring for feedback bellows height adjustment	86949
BM	Feedback-bellows height adjustment nut (1/8"-60)	52410
BN	Rocker-arm-bearing bracket complete	86956
BP	Rocker-arm-bearing stud	86954
BQ	Free-vane lever and shaft assembly	86488
BR	Reset-bellows stop (annular ring)	88288
BS	#6-40 x 3/16" Setscrew (holding stop plug)	82401
BT	Reset-bellows stop plug	88287
BU	Nozzle screw cap	52477
	Gasket for Item BU	52493
BV	Washer	89992
<u>NOT SHOWN</u>		
NOTE: The parts listed below are used only on Dynamaster and time-program units and are not illustrated in the drawing on Page 1.		
Stop pin	} located in top mounting plate where	70226
#5-44 Hex nut	} set-point-index shaft normally goes thru.	31384
#5-44 x 7/16" Fillister-head screw ...	} parts used to lock	19525
#5-44 Hex nut	} jet arm assembly	31384
#6 Shakeproof washer	} in place	43040

INSTRUCTION NO. A1444

(Issue No. 2 of 12/52)

INSTALLATION, OPERATION AND SERVICE

FOUR-POSITION EXTERNAL MANUAL-AUTOMATIC STATIONS

INCLUDING MODELS 9T1, 9T2, 9T7, 9T8

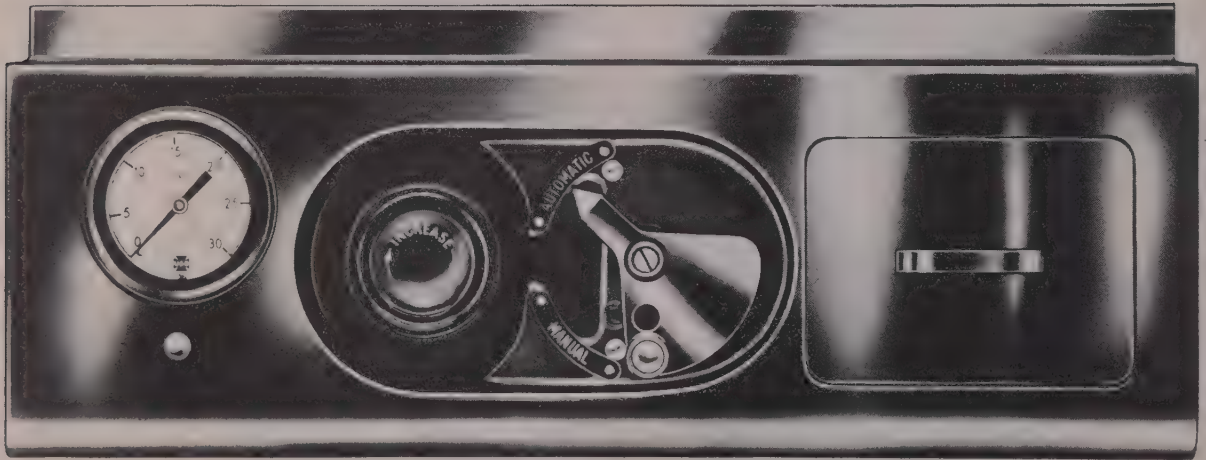


FIGURE 1. MANUAL-AUTOMATIC STATION FOR PANEL MOUNTING DIRECTLY BELOW 12-INCH SIZE BRISTOL SERIES 500 AIR-OPERATED CONTROLLERS.

PART I GENERAL

The Bristol Four-position Manual-Automatic Station is a device for transferring the control of a process to and from automatic regulation by a pneumatic controller and manual regulation by a human operator.

This instruction applies only to four-position stations. These stations provide automatic, manual, test and service positions. In addition, a push button is furnished for comparing pressures to the valve by automatic control and by manual control.

The four-position external control station includes a pressure gauge, output-air-pressure equalizing button, pressure regulator, automatic-manual valve, interlock screw, compartment cover, test valve and service valve mounted on a panel which can be mounted directly below any Bristol Series 500, 560 or 565 Pneumatic Controller or separately as required.

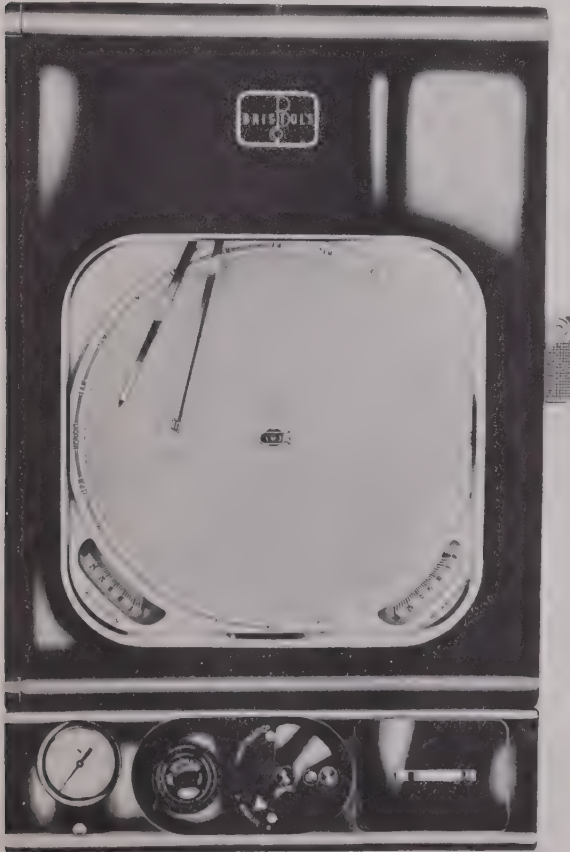


FIGURE 2. MANUAL-AUTOMATIC STATION MOUNTED ON PANEL DIRECTLY BELOW A 12-INCH BRISTOL SERIES 500 AIR-OPERATED CONTROLLER.

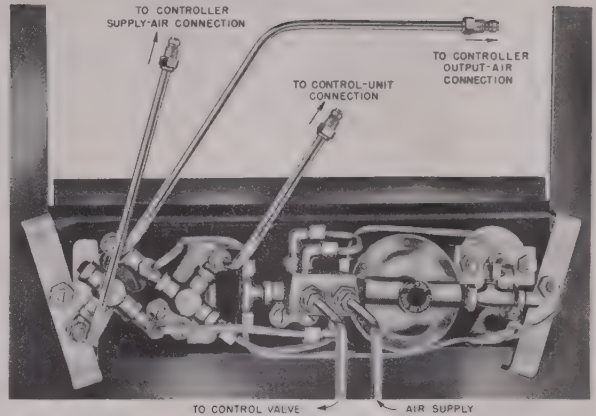


FIGURE 3. REAR VIEW OF EXTERNAL MANUAL-AUTOMATIC STATION WITH CONTROLLER REMOVED

When the external manual-automatic station is ordered together with a controller, the controller model number includes the station, connecting tubing, fittings and the necessary internal change in the controller.

When a four-position station is ordered with a controller, only the connections shown in Figure 3 or 4 need be made. If it is ordered separately for use with an existing controller, there is a tubing change necessary inside the controller case as shown in Figures 6 thru 12.

The Model 9T1 is for mounting with a Series 500 pneumatic controller and includes the necessary connecting tubing and fittings.

The Model 9T2 is for mounting separately from a Series 500 pneumatic controller, either on a panel or bracket, and includes only the necessary piece of tubing for the change required inside the instrument.

The Model 9T7 is for mounting with a Dynamaster Series 560 or 565 pneumatic controller and includes the necessary connecting tubing and fittings.

The Model 9T8 is for mounting separately from a Dynamaster Series 560 or 565 pneumatic controller, either on a panel or bracket, and includes only the necessary piece of tubing for the change required inside the instrument.

PART II INSTALLATION

There are two different installation procedures for the external manual-automatic station. Be sure that you know which installation procedure to follow. One procedure is used when the external station is ordered together with a Bristol Series 500, 560 or 565 pneumatic controller. The other procedure is used when the external station is ordered separately but for use with an existing Bristol Series 500, 560 or 565 pneumatic controller. Both installation procedures are described below.

A. Manual-Automatic Station Ordered With An Air Controller

When an external station is ordered together with an air controller, there are tubing changes inside the controller that will be made at the factory. These changes are shown in Figures 6 thru 12.

Mount the external station as required (see mounting dimensions) and connect

the external tubing as shown in Figure 3 or 4.

If the tubing from the valve (or other final control element) to the connection on the back of the external station marked "VALVE" is very short, it may be necessary to install a capacity tank to prevent cycling caused by pneumatic resonance. This is covered in the instructions for the air controller.

Connect a clean, dry, oil-free source of compressed air to the hole marked "SUPPLY" in the back of the external station. A filter sump should be installed in the supply-air line near the external station.

If there is no manual regulator in the instrument, the pressure connected to the manual-automatic control station must be 20 psi (as shown on the instrument supply-air gauge). If there is a manual regulator in the instrument*, the supply pressure may be as much as 75 psi because the internal regulator will reduce it for the instrument to show 20 psi on the supply-air gauge.

Be careful that regulators are not wide open when a pressure greater than 20 psi is connected to them.

B. Manual-Automatic Station Ordered Alone

When an external station is ordered separately but for use with an existing air controller, there are tubing changes inside the controller that must be made by the customer. These changes are shown

*Dynamasters do not have internal regulators.

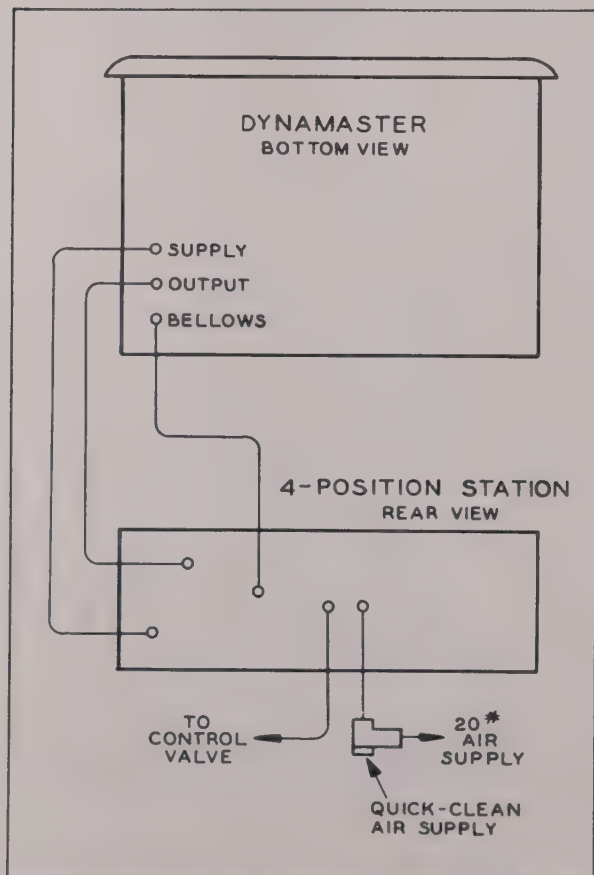


FIGURE 4. PIPING DIAGRAM - DYNAMASTER WITH EXTERNAL STATION

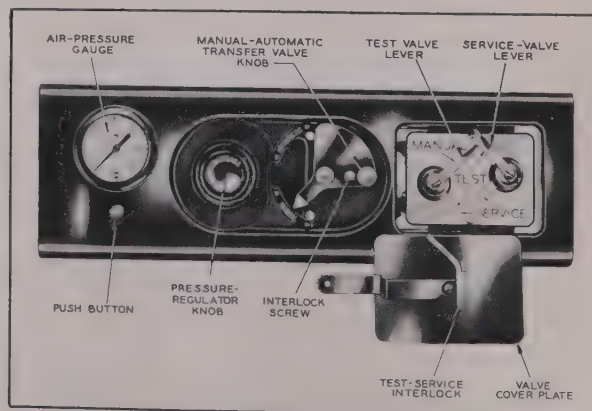


FIGURE 5. FRONT VIEW OF EXTERNAL STATION WITH VALVE COVER PLATE REMOVED

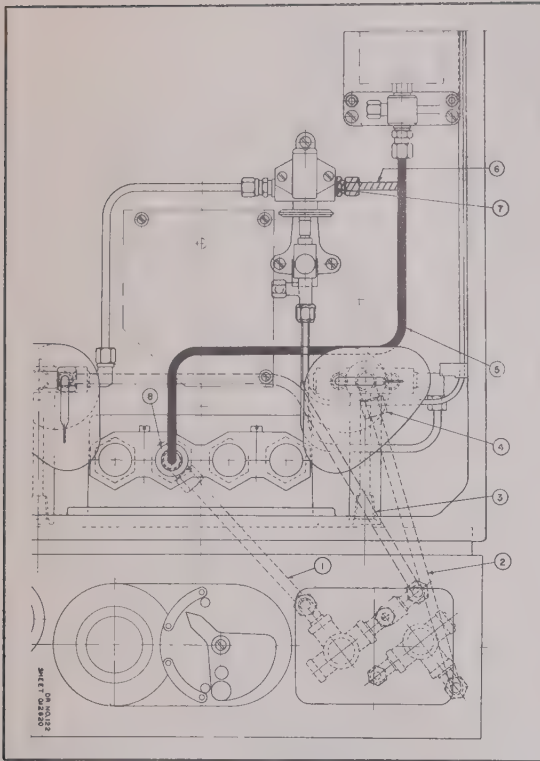


FIGURE 6. TUBING CONNECTIONS FOR SERIES 500 PROPORTIONAL CONTROLLER

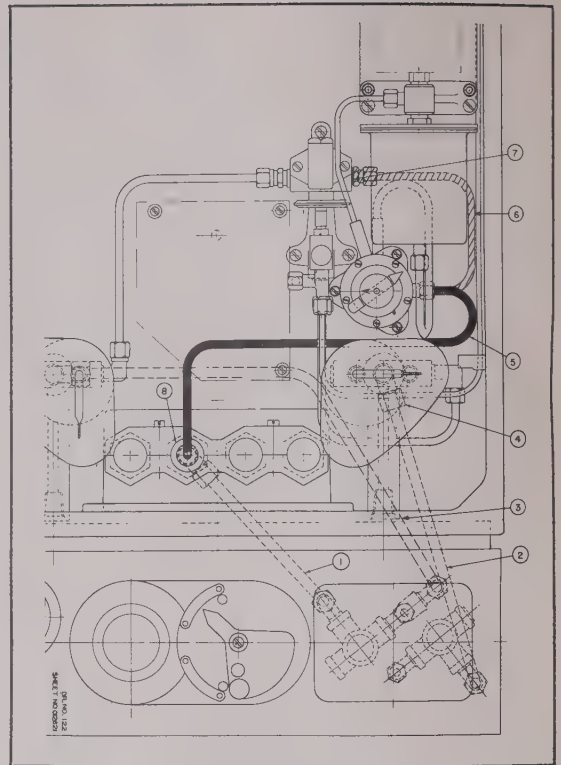


FIGURE 7. TUBING CONNECTIONS FOR SERIES 500 RESET CONTROLLER

CODE TO FIGURES 6 THRU 12

- 1, 2, 3 - Tubing for connecting external manual-automatic station to a Series "500" air controller.
- 4 - Compression elbow.
- 5 - Tubing to be installed when external manual-automatic stations are ordered separately from the controller.
- 6 - Tubing to be removed when external manual-automatic stations are ordered separately from the controller.
- 7 - Plug to be installed when external manual-automatic stations are ordered separately from the controller.
- 8 - Case connection.

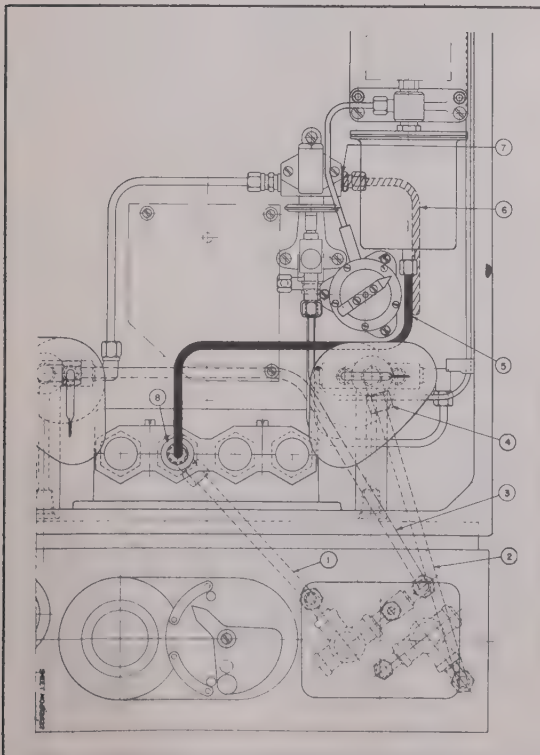


FIGURE 8. TUBING CONNECTIONS FOR SERIES 500 DERIVATIVE OR RESET PLUS DERIVATIVE CONTROLLER

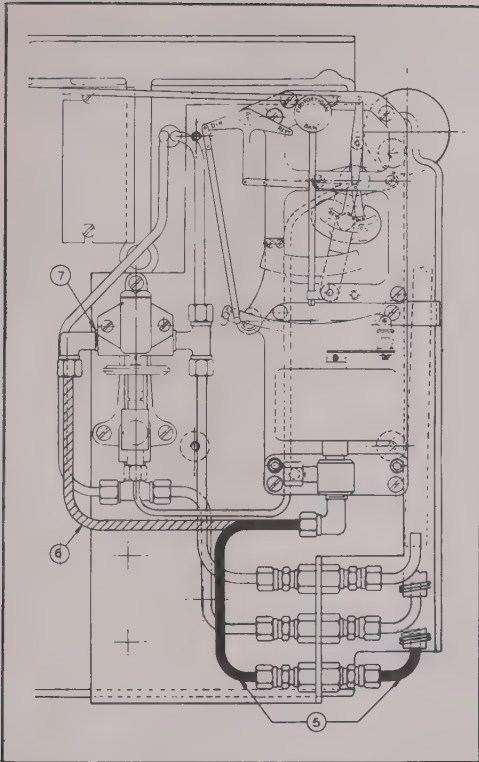


FIGURE 9. TUBING CONNECTIONS FOR SERIES 560 OR 565 DYNAMASTER PROPORTIONAL CONTROLLER

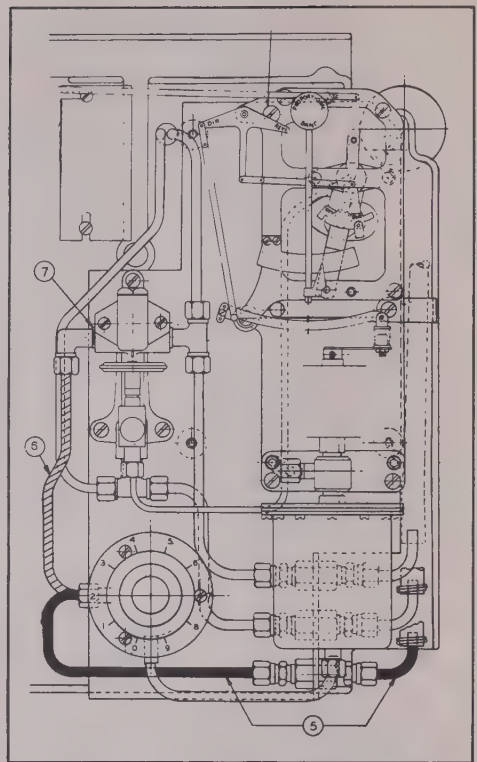


FIGURE 10. TUBING CONNECTIONS FOR SERIES 560 OR 565 DYNAMASTER DERIVATIVE CONTROLLER

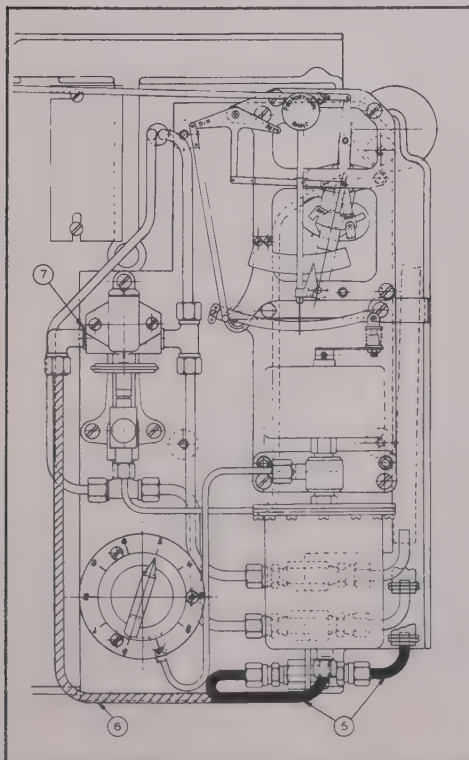


FIGURE 11. TUBING CONNECTIONS FOR SERIES 560 OR 565 DYNAMASTER RESET CONTROLLER

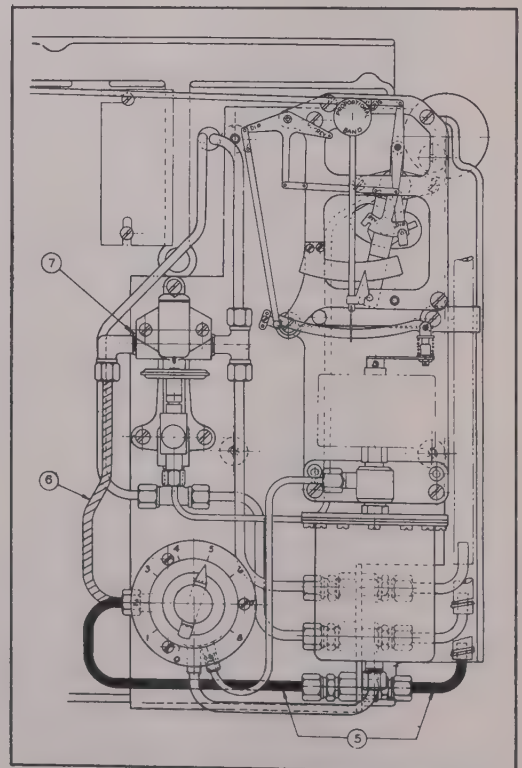


FIGURE 12. TUBING CONNECTIONS FOR SERIES 560 OR 565 DYNAMASTER RESET PLUS DERIVATIVE CONTROLLER

in Figures 6 thru 12. Be sure that you identify your instrument correctly (i.e., reset, reset plus derivative, derivative or proportional). Then select the corresponding diagram. Remove the internal tubing that is shown cross-hatched and connect the new tubing that is shown solid.

Mount the external station as required (see mounting dimensions) and connect the external tubing as shown in Figure 3 or 4.

If the tubing from the valve (or other final control element) to the connection on the back of the external station marked "VALVE" is very short, it may be necessary to install a capacity tank to prevent cycling caused by pneumatic resonance. This is covered in the instructions for the air controller.

Connect a clean, dry, oil-free source of compressed air to the hole marked "SUPPLY" in the back of the external station. A filter sump should be installed in the supply-air line near the external station.

If there is no manual regulator in the instrument, the pressure connected to the manual-automatic control station must be 20 psi (as shown on the instrument supply-air gauge). If there is a manual regulator in the instrument*, the supply pressure may be as much as 75 psi because the internal regulator will reduce it for the instrument to show 20 psi on the supply-air gauge.

Be careful that regulators are not wide open when a pressure greater than 20 psi is connected to them.

*Dynamasters do not have internal regulators

PART III OPERATION

A. Manual-Automatic Accessories

The four-position external control station has a safety feature which prevents the operator from removing the cover on the test and service valves until the manual-automatic valve has been turned to manual.

1. Automatic Position. (See Figure 5.) In the automatic position, the process is under complete automatic control. Turning the pressure-regulator-valve knob on the panel will change the reading on the panel air-pressure gauge but will have no effect on the process. Pushing the equalizing push button will make the panel gauge read the output-air pressure of the controller as shown on

the controller output-air gauge. Both should be the same when the button is pushed (see schematic diagram, Fig. 13).

2. Manual Position. (See Figure 5.) In the manual position, the process is under complete manual control. Turning the pressure-regulator-valve knob on the panel will change the position of the control valve and affect the process. By allowing the manually controlled pressure to go to the controller as well as the control valve (see schematic diagram, Figure 14), the reset system is automatically balanced and always ready for changing back to automatic control.

3. Test Position. (See Figure 5.) The test position is set up by turning

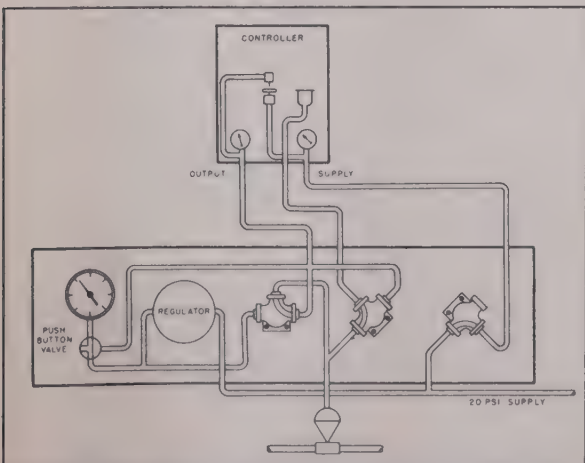


FIGURE 13. SCHEMATIC DIAGRAM OF EXTERNAL STATION IN AUTOMATIC POSITION

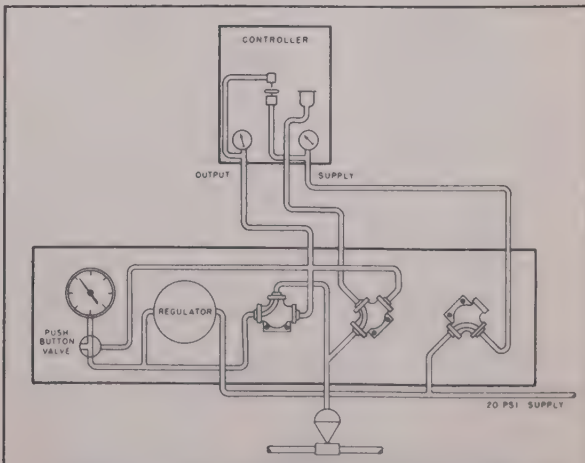


FIGURE 14. SCHEMATIC DIAGRAM OF EXTERNAL STATION IN MANUAL POSITION

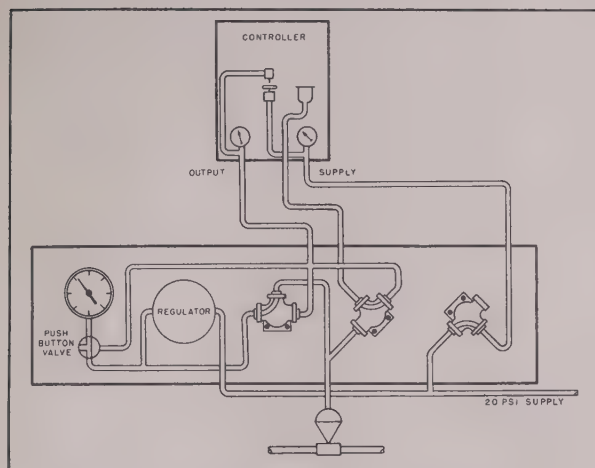


FIGURE 15. SCHEMATIC DIAGRAM OF EXTERNAL STATION IN TEST POSITION

the manual-automatic valve to the manual position and loosening the interlock screw until the valve cover plate can be removed. Then turn the test valve lever down. Leave the service valve lever up.

In this test position, the process is under complete manual control. Turning the pressure-regulator-valve knob on the panel will change the position of the final control valve and affect the process. The manually controlled pressure is not allowed to go to the controller in the test position (see schematic diagram, Figure 15), leaving the controller free for testing.

Although this test position unbalances the reset system (relative to the measured variable), it can be seen by the valve-handle arrangement in Figure 5 that it is impossible to switch to automatic control without going through the manual position. As explained in the preceding paragraph,

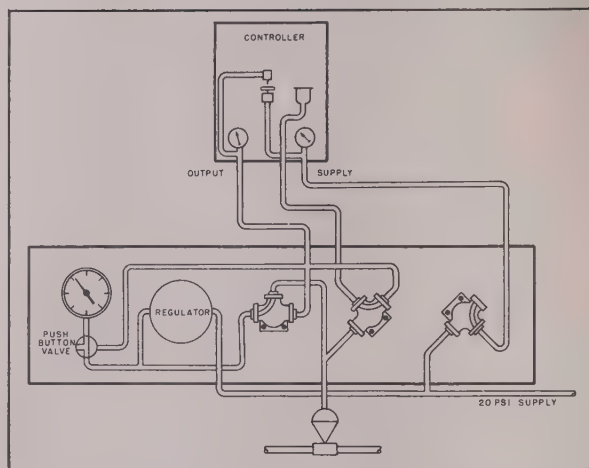


FIGURE 16. SCHEMATIC DIAGRAM OF EXTERNAL STATION IN SERVICE POSITION

the manual position allows the reset system to balance before switching to automatic. Thus, it is not possible to upset control by inadvertently turning the wrong valve.

4. Service Position. (See Figure 5.) The service position is set up by turning the manual-automatic valve to the manual position and loosening the interlock screw until the valve cover plate can be removed. Then turn the test valve lever down; turn the service valve lever down.

In this service position, the process is under complete manual control. Turning the pressure-regulator-valve knob on the panel will change the position of the final control valve and affect the process. In the service position, the controller may be completely disconnected and taken out for repair or replacement (see schematic diagram, Figure 16).

PART IV SERVICE

A. External Manual-Automatic Station

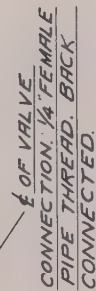
External stations require only the care given any air-operated controller. Unfavorable conditions such as vibration, corrosive fumes, dirty air supplies, etc., may eventually cause leakage or deterioration. Leaks can be found by applying a soapy-water solution to all joints and fittings and watching for bubbles.

B. Repairs, Shipping and Correspondence

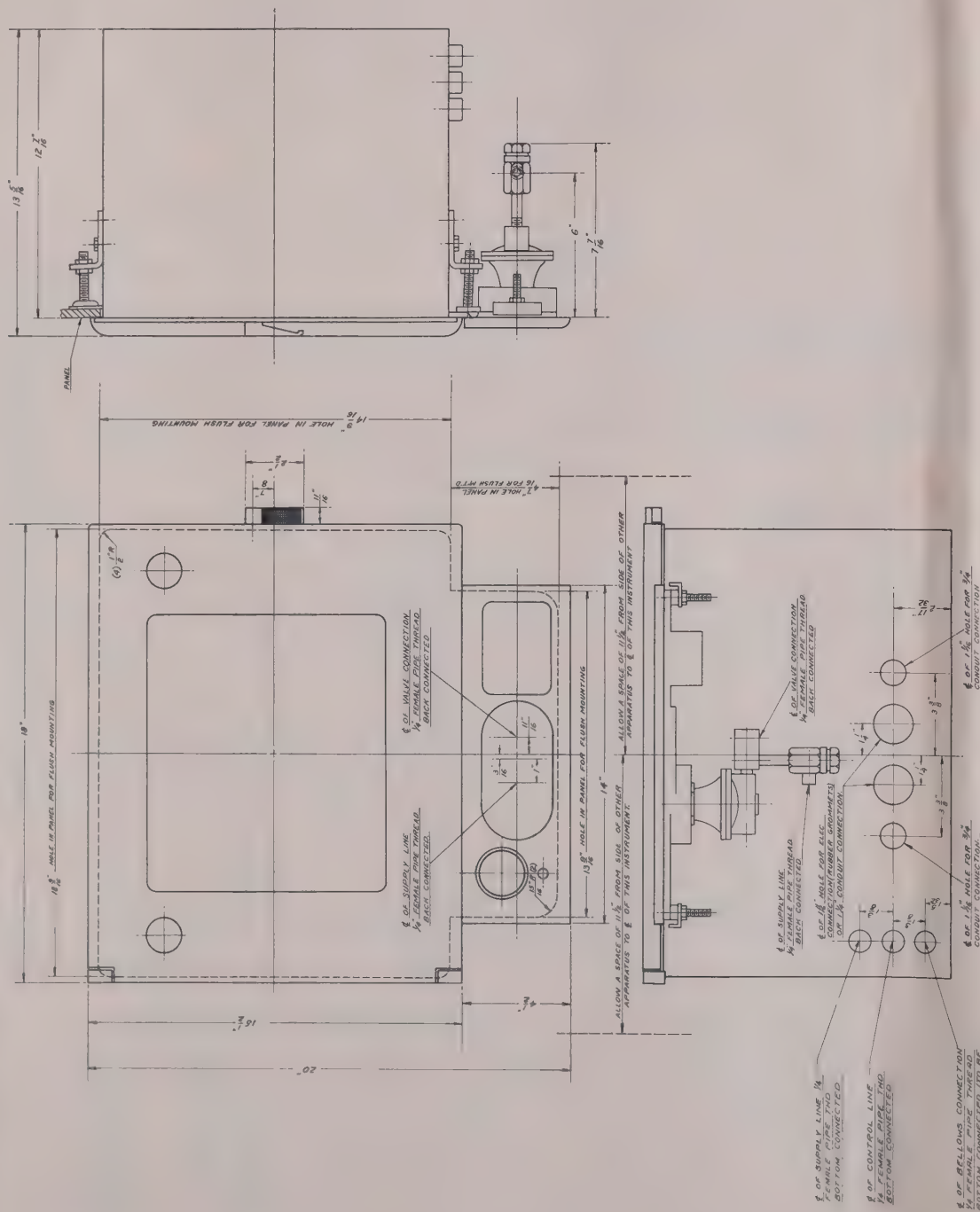
Any instrument or accessory sent to The Bristol Company for repair or replacement should be sent to the main or branch factories, not to branch offices. Be sure to mark your return address plainly.

In all correspondence, please mention the instrument model and serial number and your repair order number. Address all correspondence to The Bristol Company main or branch offices, a list of which is found in all instruction manuals.

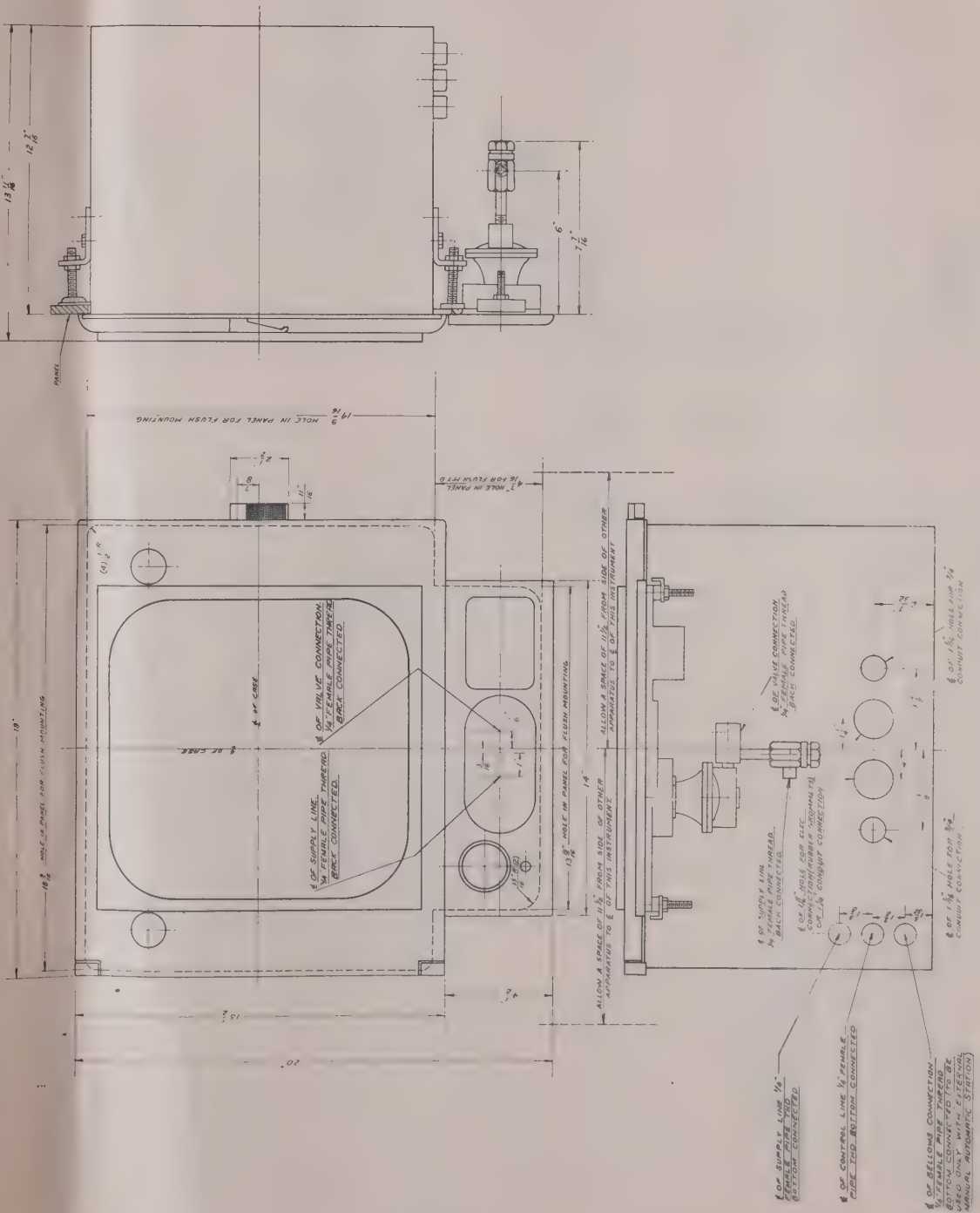




OVERALL AND MOUNTING DIMENSIONS
FOR MODEL 9T2 OR 9T8 EXTERNAL MANUAL-AUTOMATIC STATION



OVERALL AND MOUNTING DIMENSIONS.



OVERALL AND MOUNTING DIMENSIONS
SERIES 565 F.V. CONTROLLER WITH EXTERNAL MANUAL-AUTOMATIC STATION

INSTRUCTION NO. Y19200
(Issue No. 1 of 12/55)

ADJUSTMENT OF BLIND-SET ALARM CONTACTS

ATTACHMENT SPECS. E20, E21, E22, E23, E31, etc.

USED ON THE 560 AND 565 SERIES INSTRUMENTS

Herewith: Wiring Diagram as required

A. Description

Blind-set alarm contacts are located on the back of the swinging panel and consist of from one to three microswitches, cam rollers and cams to provide various alarm circuits. The cams are mounted on the same shaft that moves the sliding contact on the slide wire. The switches are used primarily to operate alarms or signal lights and are entirely independent of any other control circuit that may be in the instrument.

B. Wiring

A wiring diagram will be furnished with this instruction to cover the particular alarm circuit ordered. The alarm terminals are plainly marked on all instruments and correspond to the markings on the wiring diagram.

The power for operating the alarm may come from any source, such as a battery or a-c power supply.

The maximum recommended capacity of the microswitches is 10 amperes at 120 volts a-c, 5 amperes at 240 volts a-c, 1/2 ampere at 115 volts d-c, 1/4 ampere at 240 volts d-c.

C. Adjustment

The switches are factory adjusted to operate at the point or points specified on the order. If it is ever necessary to change the operating point of the alarm switch or switches, it may be done as follows:

1. On Single-switch Single-cam Alarms. Turn instrument power switch off. Move indicating pointer, by means of the bull gear or motor pinion, to the point on the scale at which the alarm is to operate. Hold bull gear tight to prevent indicating pointer from moving and then rotate the cam until the cam-follower roller drops into the notch in the cam to operate the switch. The cam is held in place by a friction disc and a lock nut. The cam may be moved without loosening its lock nut. After shifting the position of the cam, be sure the adjusting nut is tight so as to hold the cam securely in position. The direction the cam should be rotated depends on the locating of the notch in the cam with respect to the roller. If the notch is to the left, the cam should be rotated

clockwise. If the notch is to the right, the cam should be rotated counter-clockwise.

2. On Two- and Three-switch Alarms. Turn instrument power switch off. Adjust switches in the same manner as on the single-switch alarm.

Each seitch has its own cam and may be adjusted independently of the others.

THE BRISTOL COMPANY
WATERBURY 20, CONN. U.S.A.

INSTRUCTION NO. W18210A
(Issue No. 1 of 6/53)

OPERATION OF BRISTOL'S DYNAMASTER
TIME-PROGRAM CONTROLLER IN THE SERIES 565 CASE

Herewith: Photos 15787B, 15788B
Diagrams 013358, 013923

Note: This instruction covers only the operation of the Time-program Control. See separate instructions covering installation, operation and service of the measuring element, recording system and control system, as required.

PART I GENERAL DESCRIPTION

This instrument is designed to control a measured variable (usually temperature) by means of pneumatic or electronic control equipment built into the case. The set point, instead of being shifted manually as on standard controllers, is shifted continuously by a cam follower riding on the periphery of a transparent cam cut according to the desired program.

The Dynamaster time-program controller is a single-case recording-type instrument with the transparent control cam mounted in front of the chart.

A. Functions of the Various Parts

1. Cam Motor. The cam motor will operate when the toggle switch on the left side of chart plate is thrown to the on position and the limit switch is in its running position. The cam motor will stop when the cam follower drops below the point to which the limit switch has been set. The cam motor may be stopped at any time by moving toggle switch to the off position.

2. Green Light. This light lights when the cam motor is running.

3. Red Light. This light lights when the cam motor stops.

4. Toggle Switch. The toggle switch located on the left side of the chart plate is used to start or stop the cam motor.

5. Limit Switch. The function of this switch is to stop the cam motor automatically at the end of the desired period. This is accomplished by cutting the cam with a drop at the end of the cycle. The drop should be at least 5% below the starting point of the program.

6. Cam. The function of the cam is to provide a means of automatically shifting the set point to get the desired program.

PART II OPERATION

A. How to Cut Cams

The transparent cams furnished with time-program controllers may be cut with a band saw and then filed smooth. It is first necessary to outline in pencil on a chart the particular program desired. There is a limit to the amount of rise at any particular point on the chart. A drawing is provided with this instruction, outlining a convenient template to be used in checking any particular cam rise. This template may be cut out of transparent celluloid or any other transparent material, or of necessity may be used as is. When the template is cut out, it should be rotated around the chart center to see that the slope on any portion of the program outline does not exceed the rise represented by the reference edge of the template.

After the program outline has been correctly drawn on the chart, place the transparent cam over the chart, making sure to center the cam over the chart. With any pointed instrument, scribe the outline of the program on the cam. Then cut the cam on a band saw as close to the scribed line as practical and then file the balance smooth to the exact program line.

B. How to Adjust the Limit Switch

The limit switch is mounted on a gear-segment plate which is located on the back of the panel. This plate is locked in position by two screws. In order to adjust the limit switch, it is necessary to loosen these two screws and turn the knurled pinion which engages the teeth of the gear segment until the red light lights and the cam motor stops. Be sure to retighten the two locking screws after any adjustment. If a continuous cam rotation is desired, the limit switch may be shifted to operate above the upper limits of the cam contour.

C. How to Start

With cam switch in the off position, turn instrument power switch on. Red light will light. Turn cam counterclockwise by means of the red knob on the upper right side of the instrument until cam follower is at the proper starting point. Do not turn cam directly by hand. Then turn cam switch on. Cam motor will start, green light lights and red light goes out.

Note: If instrument has an electronic control, allow 30 seconds for tubes to warm up before starting cam motor.

Next, turn on the controlled variable. As the cam follower mechanically moves the set point, the controller acts to control the measured variable in accordance with the cam contour.

If the limit switch is adjusted properly, the cam will stop when the cam follower drops off the drop cut in the cam at the end of the cycle. When the cam motor stops, the green light will go out and the red light will go on. Cam motor may be stopped at any time by throwing cam switch to the off position.

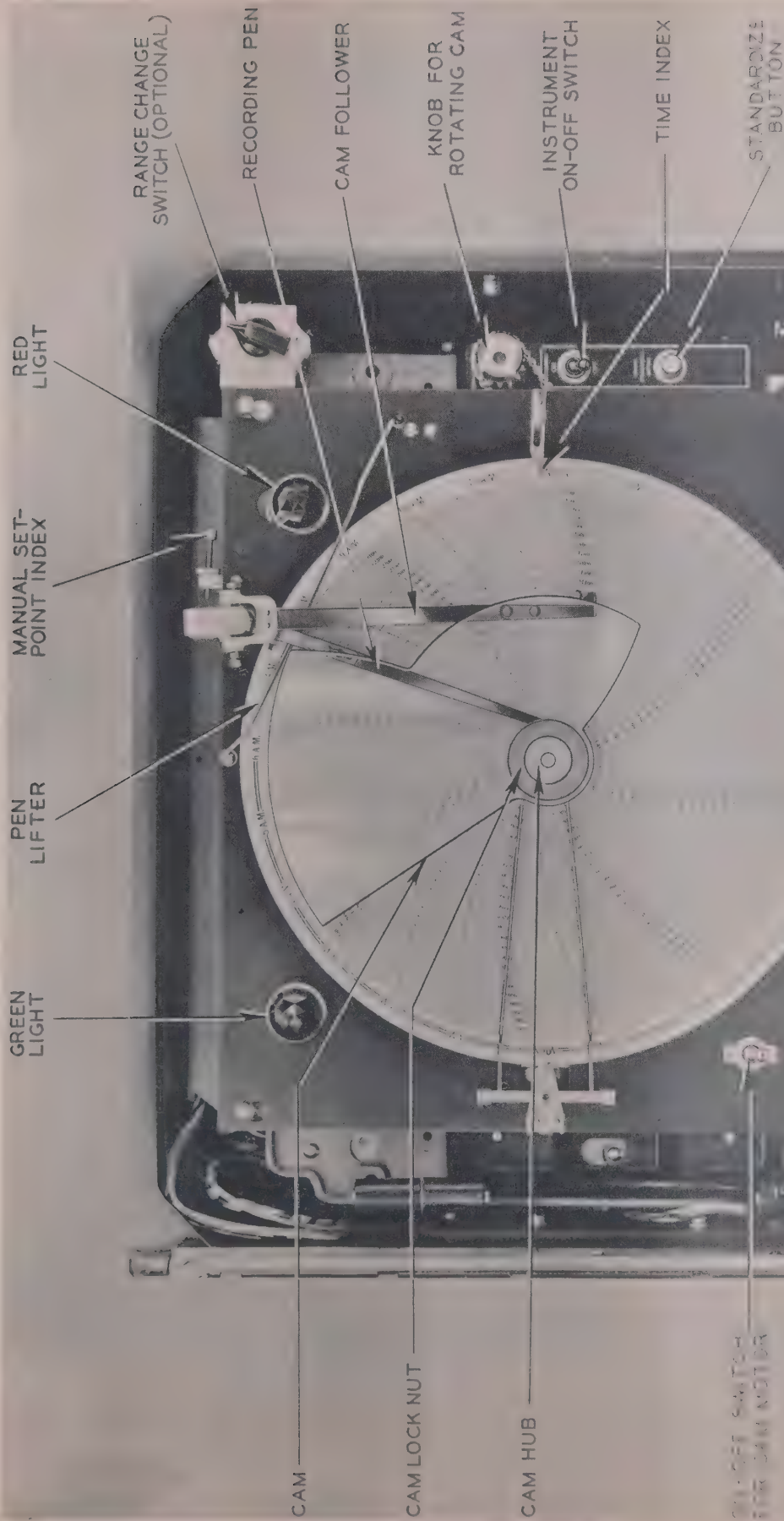
D. How to Change Charts

1. Move cam follower to top of scale by means of knurled knob at center of cam-follower-arm support.

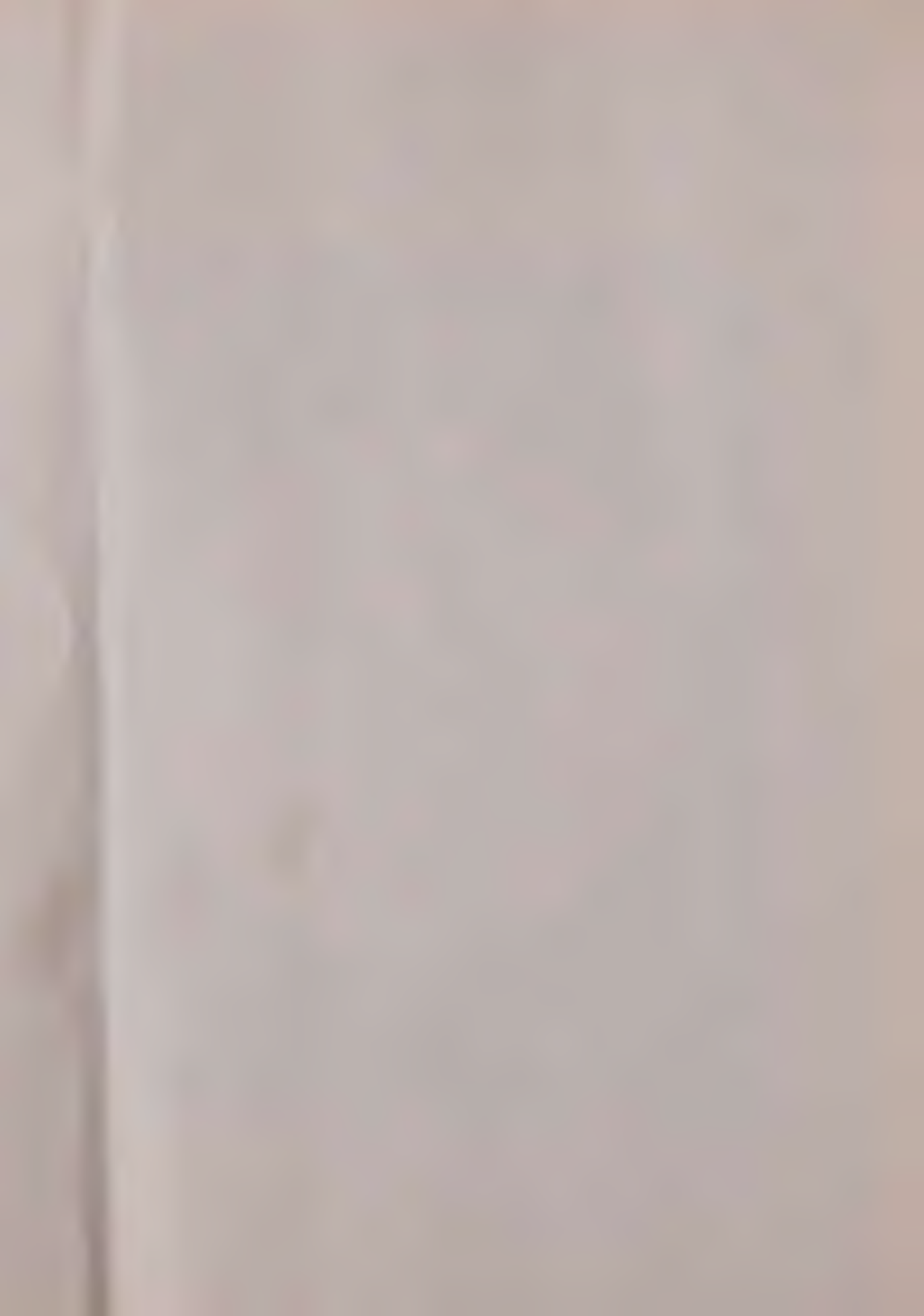
2. Swing program cam to left on hinged support.
3. Lower cam follower to zero position.
4. Raise pen lifter.
5. Push time index to right.
6. Replace old chart with new one.
7. Push time index to left.
8. Lower pen lifter.
9. Move cam follower to top of scale. Hold in this position while returning cam to center drive hub.
10. Rotate cam to starting position by means of red knob on right-hand side of instrument. Caution: Do not rotate cam directly by hand. Always use red knob.

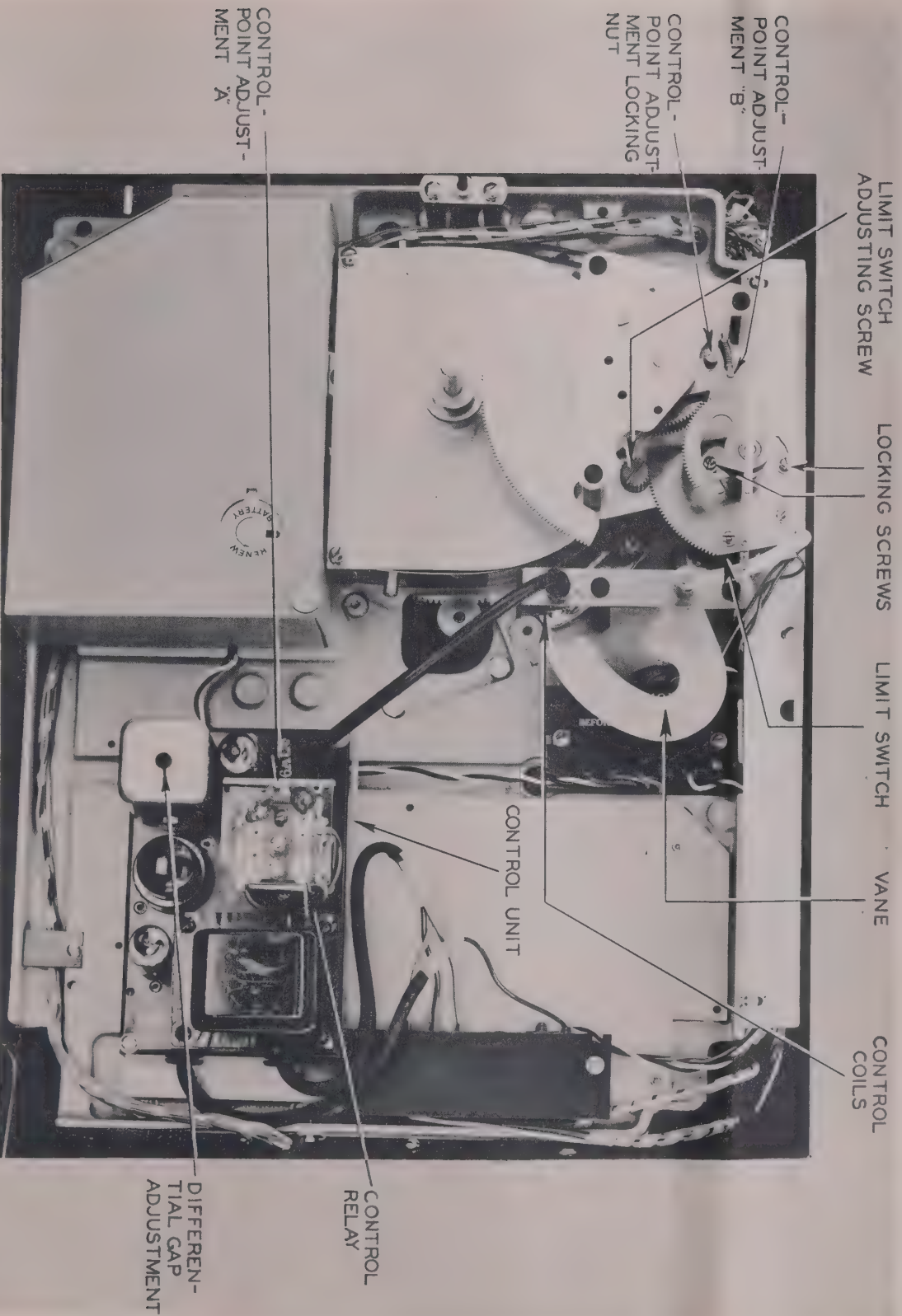
THE BRISTOL COMPANY
WATERBURY 20, CONNECTICUT, U. S. A.





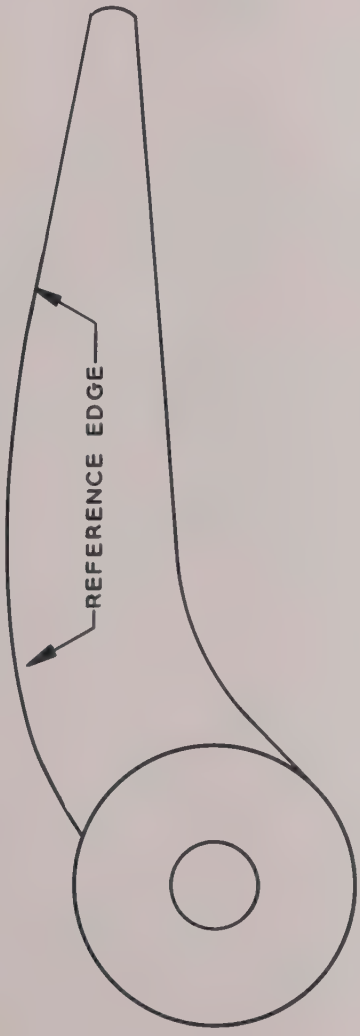
DYNAMASTER TIME PROGRAM CONTROLLER
(FRONT OF HINGED PANEL)





DYNAMASTER TIME-PROGRAM CONTROLLER
 WITH ELECTRONIC CONTROL UNIT (BACK OF PANEL)

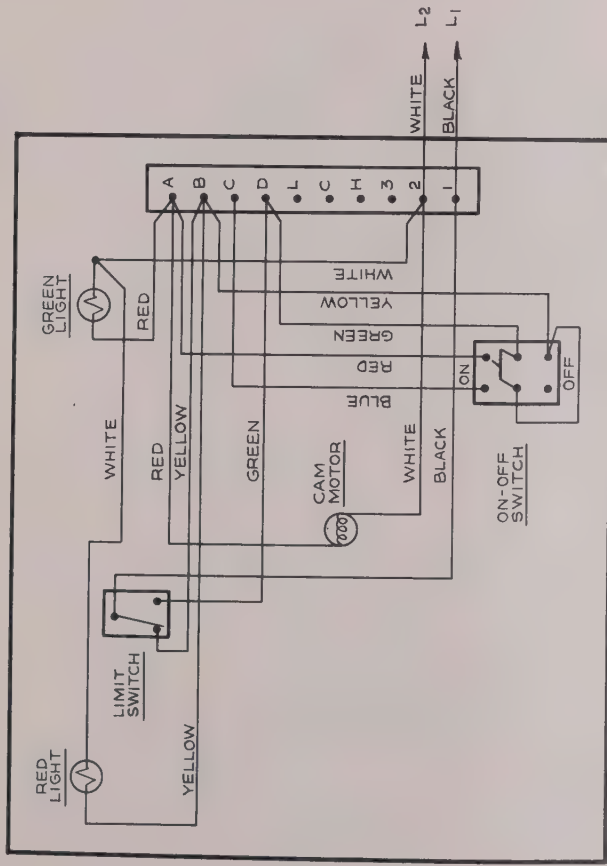
NOTE: THE SLOPE OF ANY CAM RISE SHOULD ALWAYS BE WITHIN THE SLOPE REPRESENTED BY THE REFERENCE EDGE OF THE TEMPLATE. SEE INSTRUCTIONS W18210



DRAWING OF TEMPLATE USED TO CHECK CAM SLOPES ON TIME PROGRAM CONTROLLERS IN SERIES 565 CASE

DATE	7-21-52	BY	I.J.F.
APPROVED	21	013358	

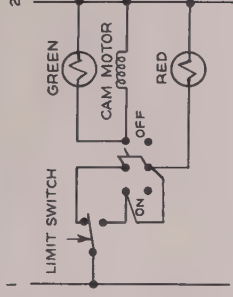
REAR VIEW OF HINGED PANEL



TO MAIN POWER
SUPPLY TERMINAL
BLOCK

WHITE L₂
BLACK L₁

SCHEMATIC WIRING



COLOR CODE

- A RED
- B YELLOW
- C BLUE
- D GREEN
- 1 BLACK
- 2 WHITE

WIRING DIAGRAM

FOR DYNAMASTER TIME-PROGRAM CONTROLLER WITH SIGNAL LIGHTS,
MANUAL SWITCH & LIMIT SWITCH (ATTACHMENT SPECS. G22X & N17X OR T62, & N15

B CO. ORDER NO. [] CUSTOMER ORDER NO. [] SERIAL NO. []

DATE 11-16-56 DIVISION []

THE BRIDGES COMPANY
WATERTOWN, U.S.A.
DRAWN MKC
DATE 6-10-53 DRAWER # 122
013923

NOTES:

1. IF TIMING MOTOR IS REQUIRED THE STANDARDIZING MICRO-SWITCH AND TIMING MOTOR ARE LOCATED & WIRED AS SHOWN IN DOTTED LINES BELOW.
2. SEE SEPARATE SHEET FOR MEASURING CIRCUIT WIRING.
3. FAILSAFE LEADS TO BE CONNECTED TO CORRESPONDING COLORS ON AMPLIFIER TERMINAL BLOCK.

ROTARY SOLENOID (OPTIONAL ON RECORDERS ONLY)

RECTIFIER

ON-OFF SWITCH

CHART DRIVE SWITCH (OPTIONAL)

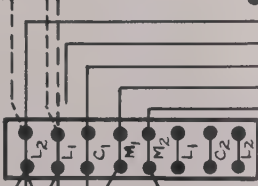
PUSH BUTTON STANDARDIZING SWITCH

* FOR WIDE STRIP ONLY
** FOR WIDE STRIP HIGH SPEED CHART DRIVE ONLY

STANDARDIZING RELAY

BALANCING MOTOR

WHITE
BLACK



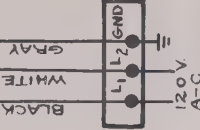
WHITE
BLACK

CHART DRIVE

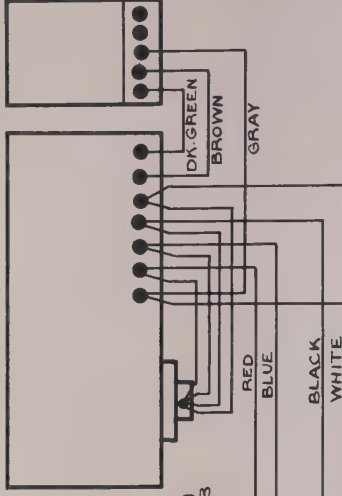
** CAP.

*TERM. BLOCK

TIMING MOTOR FOR STANDARDIZING MICRO-SWITCH (SEE NOTE 2)



AMPLIFIER C1



VACUUM TUBE FAILSAFE (OPTIONAL) SEE NOTE 3

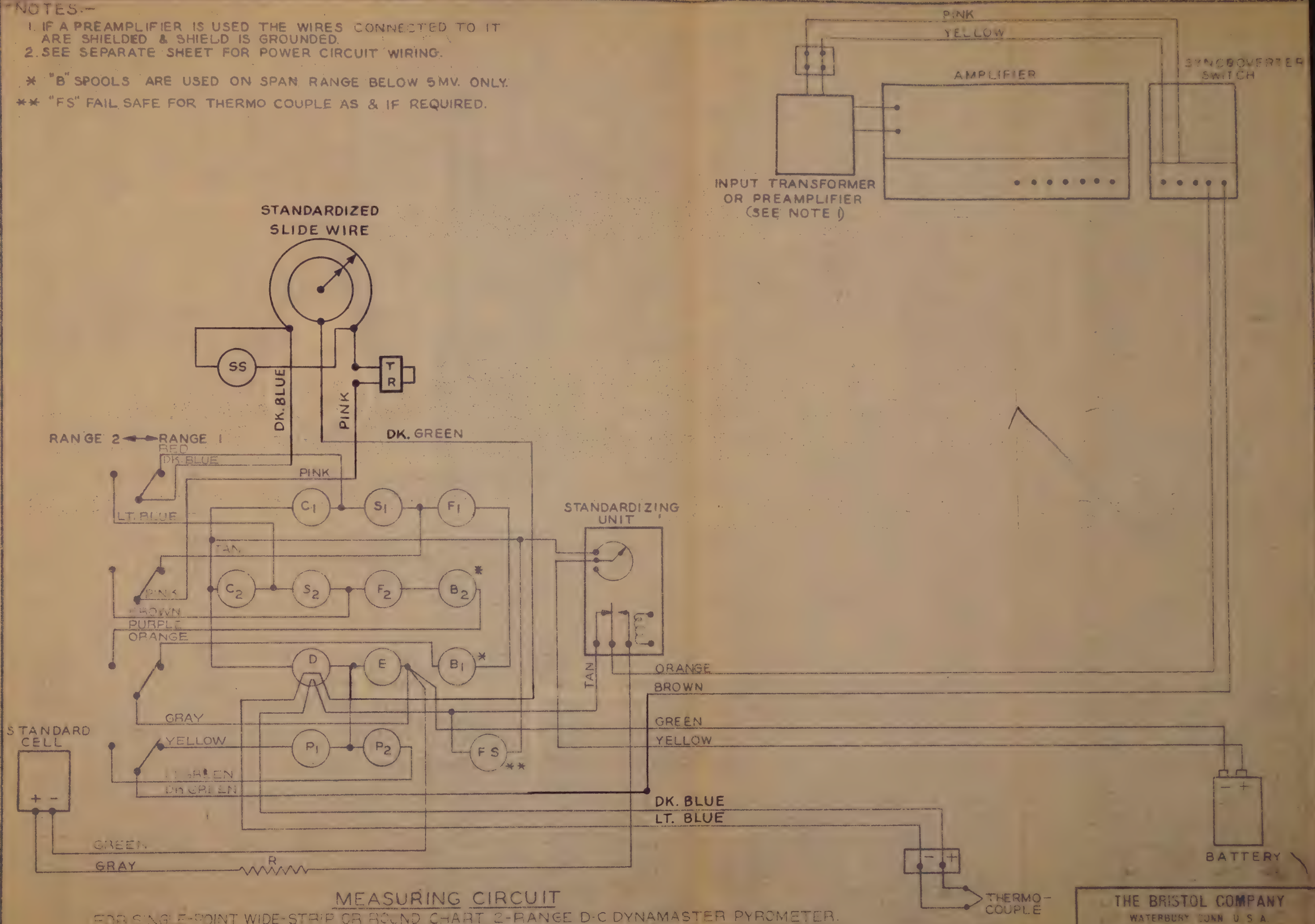
POWER CIRCUIT WIRING DIAGRAM

FOR SINGLE-POINT WIDE-STRIP OR ROUND-CHART DYNAMOMETER POTENTIOMETER INDICATOR OR RECORDER.
FOR USE WITH SERIES C1 AMPLIFIER.



NOTES:-

- 1. IF A PREAMPLIFIER IS USED THE WIRES CONNECTED TO IT ARE SHIELDED & SHIELD IS GROUNDED.
- 2. SEE SEPARATE SHEET FOR POWER CIRCUIT WIRING.
- * "B" SPOOLS ARE USED ON SPAN RANGE BELOW 5MV. ONLY.
- ** "FS" FAIL SAFE FOR THERMO COUPLE AS & IF REQUIRED.



MEASURING CIRCUIT

FOR SINGLE-POINT WIDE-STRIP OR ROUND CHART 2-RANGE D-C DYNAMASTER PYROMETER.

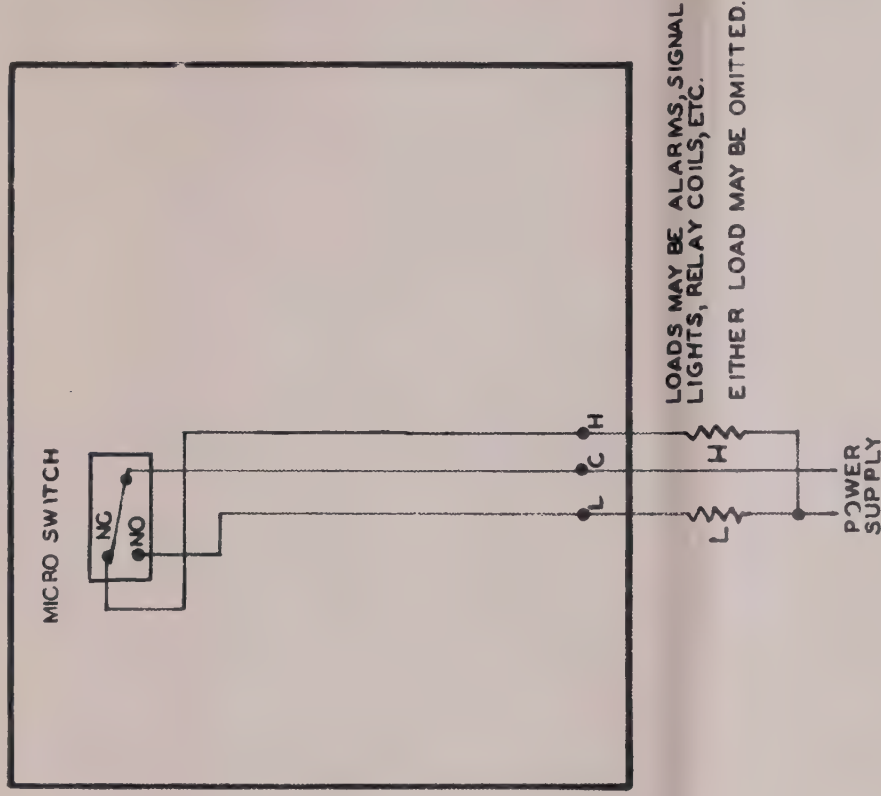
WITH STANDARDIZED SLIDE WIRE

B. CO. ORDER NO.	CUSTOMER ORDER NO.	SERIAL NO.	9-30-55	REVISION DATES	DRAWN <u>LE</u> TRACED	DATE <u>4-13-54</u> DRAWER NO <u>122</u>	SHEET NO <u>014410</u>
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MAXIMUM RECOMMENDED CAPACITY OF MICRO SWITCHES

10 AMPS.	AT	120 V. A-C
5 AMPS.	AT	240 V. A-C
1/2 AMP.	AT	120 V. D-C
1/4 AMP.	AT	240 V. D-C

DYNAMASTER



TRACED 7-24-56 JA

WIRING DIAGRAM

HIGH OR LOW ALARM CONTACTS (SPEC. E20, F22, E27, E35, E37 & E42)

2-27-51

I.J.F.

21

012678

HOW TO ORDER PARTS AND SUPPLIES FOR BRISTOL PRODUCTS

In all correspondence concerning any product of the Bristol Company, always give the model and serial number of the product concerned. Send your purchase order or quotation request to the nearest Bristol Company Branch Office (see the back of this sheet for addresses).

REPLACEMENT PARTS

When ordering replacement parts look up the part name and number in the parts list provided with the instructions that came with your product. When you cannot find a part number, give an accurate description of the part. If you have mislaid your parts list write for a new one giving the model and serial number of the product.

CHARTS

In ordering charts for recorders, give the chart number (printed on the chart and also on the instrument name plate).

Avoid inconvenient emergency orders by keeping a six months supply of charts on hand for each of your recorders.

THERMOCOUPLES

Pyrometer thermocouples should be ordered from Bulletin P-1238. Be sure to specify the catalog number and the length. If you do not have Bulletin P-1238, write for one.

Pyrometer users should always have a supply of spare thermocouples.

SAMPLE PURCHASE ORDER:

QUANTITY REQUIRED	DESCRIPTION	PART, CHART OR CATALOG NUMBER
1000	Charts, 0° to 1500°F	5342
5	7-day electric chart drive for 115 volts, 60 cycles	86226
4	Pen arms marked CD	49703
1	Knurled plastic knob on outside of case, ½" diameter, 3/16" hole for moving, set-point index	none given
1	1 oz. bottle red ink	6883
	The above parts are for a Bristol thermometer con- troller Model 1T1X500B-2, serial number 767211.	
4	IC thermocouples, length 30"	3BS14N2
	The above thermocouples are for a Bristol pyrometer Model 487-L, serial number 202953	

THE BRISTOL COMPANY • Waterbury 20, Conn.

BRANCH OFFICES

ALABAMA		
Birmingham 3, 324 Comer Building	3-0034	
CALIFORNIA		
Los Angeles 58, 2181 E. 25th Street	Ludlow 8-4109	
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COLORADO		
Denver 16, 4556 East 46th Avenue	Dexter 3-6228	
CONNECTICUT		
Hartford	Enterprise 4050	
Waterbury 20, Bristol Road	Plaza 6-4451	
DELAWARE		
Wilmington	4-1183	
DISTRICT OF COLUMBIA		
Washington	Republic 7-0655	
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New Orleans	WX-2881	
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Detroit 21, 10329 W. McNichols Rd.	University 4-4284	
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Newark, 970 Broad Street	Mitchell 2-6823	
NEW YORK		
Buffalo 7, 1807 Elmwood Avenue	Delaware 3754	
New York 19, 250 West 57th Street	Circle 5-4953	
No. Syracuse, P.O. Box 177	66-3653	
NORTH CAROLINA		
Charlotte, P. O. Box 3180	Franklin 5-7658	
OHIO		
Akron	Enterprise 4146	
Cincinnati 37, 1717 Section Rd., Room C-4 ..	Elmhurst 1-0328	
Cleveland 2, 8905 Lake Avenue	Atlantic 1-6924	
Columbus 15, 101 N. High Street	Capitol 1-6133	
OKLAHOMA		
Tulsa 3, 304-A Daniel Building	Luther 4-2178	
PENNSYLVANIA		
Philadelphia 7, Market St. National Bank Bldg.	Rittenhouse 6-2386	
Pittsburgh 5, 2250 Noblestown Road	Walnut 2-2100	
TENNESSEE		
Knoxville, P. O. Box 202	5-5992	
TEXAS		
Houston 19, 1705 West Gray Avenue	Jackson 4-2881	
WASHINGTON		
Seattle 1, 101 Jones Building	Elliott 3361	
WISCONSIN		
Milwaukee 2, 735 N. Water St., Rm. 1327 ..	Broadway 6-4393	

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SAN FRANCISCO 7, CAL. — 40 Berry Street

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THE BRISTOL COMPANY OF CANADA LIMITED

71-79 Duchess Street, Toronto 2, Ontario — Phone: Empire 3-3421
Branch Office at 1529 Drummond Street, Montreal 2, Quebec
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In Great Britain

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Lynch Lane,
Weymouth, Dorset, England



Printed in U.S.A.



A Recorder Is No Better Than Its

Chart. For 40 years Bristol engineers have worked to better methods for producing recording instrument charts. Today, all charts are printed from masters prepared from engine engraved wax originals—a method developed by us. Cooperation with our paper suppliers has produced custom made chart papers with special inhibitors to retard moisture absorption, special sizing to give just right inking, lowest dimension changes due to humidity, and perfect flatness. Paper stocks are "cured" at constant humidity & temperature until absolute uniformity of dimensions is assured and then printed in an air conditioned shop. Printing and center hole punching are done simultaneously, achieving perfect concentricity. The result is charts yielding the highest accuracy of performance under a wide variety of conditions. Bristol prints over 600,000 pounds of charts yearly. Bristol instruments are guaranteed only when using Bristol's Charts.

Buy Charts in Quantities and Save.

Discounts up to 50 and 40% are allowed on charts purchased in quantities.

Bristol's Annual Chart Requirement Plan.

Enables large users to place orders for as few as 1,000 charts at a time, yet receive discounts based on their estimated total yearly purchases. Such orders may be assorted as to size and number, but must be for shipment to any single destination. (Strip and smoked charts excluded.)

Review the chart requirements of your entire organization and save by either above plan.

Bristol Recorder Ink Is Specially

Compounded. Thirty years of laboratory development and field test have produced inks

in 8 colors—non-fading even in atmospheres containing chlorine and sulphur dioxide fumes. Bristol Standard ink possesses the right surface tension for smooth flow and clean tracings, the right drying rate for average chart speeds, and is free of solids which plug pens. Bristol makes low temperature inks which will dry but not freeze at ambient temperatures down to -65°F and high temperature inks recommended for ambient temperatures up to 400°F . It is economical to buy Bristol's ink in pint, quart and gallon bottles to refill the handy 1 ounce dropper stoppered bottles supplied with each instrument.

Use Genuine Bristol Parts.

Only Bristol replacement parts are identical with those originally built into your instrument. They assure ease of replacement and perfect performance.

● **THERMOCOUPLES** — Bristol tests thermoelectrically before shipment from our suppliers and after receipt at our factory every batch of thermocouple wire stock, accepting only those meeting precision checks against the National Bureau of Standards.

Buy Bristol's Thermocouples to obtain replacements which are exact duplicates of those for which your pyrometer was originally calibrated.

Service Chart Drives.

Both main and branch factories carry stocks of carefully rebuilt, fully guaranteed chart drives, both spring and electric, which will be exchanged for your defective chart drive for a nominal charge. Note: in order to positively identify speed, gear ratios, mounting, etc., we must receive your old chart drive before shipping the replacement.

BRISTOL FIELD SERVICE

A coordinated, nation wide instrument engineering organization planned to serve users of industrial instruments whatever their problem — wherever they are located. Staffed by genuine experts in instrument application and maintenance.

Branch Factories. Three well equipped Branch Factories located across the nation in key industrial centers to speed up repair jobs and delivery of replacement parts and supplies. Each is manned by factory trained workers using factory methods, equipment and genuine Bristol parts in all phases of fabrication, calibration and repair. Instruments reconditioned in our factories carry the same guarantee as a new instrument. Parts and supplies likely to be needed in emergencies are stocked in all Branch Factories.

Sales Offices. Twelve Sales Offices located in strategic industrial cities thruout the United States and Canada, staffed by instrument engineers with years of "know how" in solving instrumentation problems of the industries peculiar to their districts. Call on these offices for personal engineering study, technical proposals and accurate quotations on your automatic process control problems.

Field Engineers. Over 50 experienced instrument engineers—experts in applying recorders and automatic controllers to industrial processes. These are the men who go into your plant, study your process and recommend equipment best suited to your job. They are available without cost or obligation to help you plan your instrument installations.

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Available at reasonable rates to go anywhere in the United States or Canada to maintain in your Bristol instruments, thru many years of usefulness, the same high-accuracy and performance originally built into them. Bristol's Engineers make trips thru most parts of the United States, Canada, Cuba and England at frequent intervals. Avail yourself of this service by contacting the nearest Bristol Office.

Periodic Service Plan. A systematic plan designed to keep Bristol's instruments at top performance and accuracy. A Bristol Service Engineer calls periodically two to twelve times a year to inspect, check calibration, adjust, lubricate and repair all Bristol's instruments in the user's plant. We fix them before they fail! Use this plan to prevent costly lost production and product spoilage due to instrument break downs. Contact the nearest Bristol Office for full information on yearly contracts covering the Periodic Service Plan.

Technical Consulting Service. A complete consulting service based on over 50 years of experience in applying instruments to tens of thousands of widely varying processes and equipment. Just supply us with complete data—temperature and pressure ranges, flow rates, chemical characteristics, mechanical limitations, etc., and a sketch of the equipment. Our factory Application and Specialty Engineering Departments are available to advise automatic instrumentation for your tough and unusual processes.

BE SURE TO MENTION SERIAL AND MODEL NUMBERS WHEN ORDERING PARTS, INSTRUCTIONS AND DIAGRAMS

THE BRISTOL CO. WATERBURY 20, CONN.



MP MASTER



MA30033